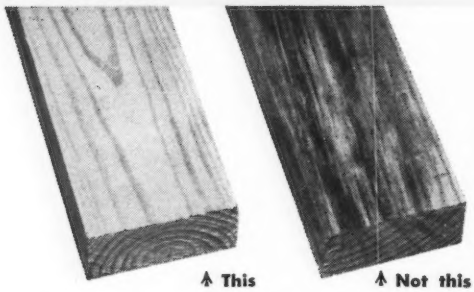
NEW METHOD OF LAMINATING LUMBER—P. 97

Forest Products Journal

Come to Asheville June 4–7 for FPRS 10th National Meeting and Suppliers Exhibit—See pages 6-A, 25-A

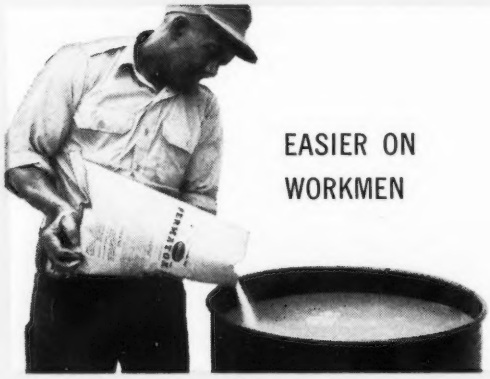
Published by the FOREST PRODUCTS RESEARCH SOCIETY BOX 2010 MADISON 5, WISCONSIN

Get bright, clean, higher-value lumber with improved PERMATOX 10-S



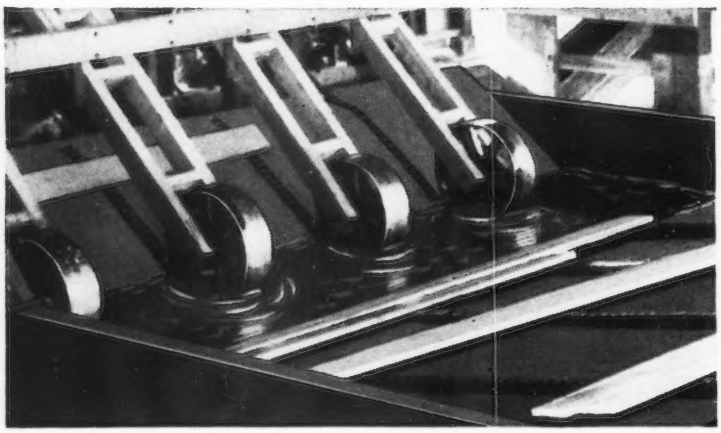
PREVENTS SAP STAIN AND MOLD

Lumber treated with Permatox 10-S is bright and clean. For a few cents per thousand you can prevent costly degrade because of sap stain and mold . . . thus insuring customer satisfaction.



EASIER ON WORKMEN

No irritating dust problem with improved Permatox 10-S. The addition of a new ingredient makes it practically dust-free, easier for workers to handle and mix than ever before.



Mechanical dipping vat, as shown here, is the usual method of applying Permatox 10-S. Lumber also can be sprayed or dipped in bulk. Hand dipping is often used at small mills. Consult Chapman for details.

Permatox 10-S

- Prevents stain, mold and decay in lumber during air seasoning.
- Costs only a few cents per thousand.
- Can be applied by dipping or spraying . . . equipment needed is inexpensive and easy to build.
- Can be mixed with Chapman Ambrocide to protect lumber from ambrosia beetles and other insects.

CHAPMAN CHEMICAL COMPANY
Memphis 1, Tennessee • Portland 9, Oregon

Write for helpful Bulletin 51-S on stain, mold and insect control.

CHAPMAN®

PERMATOX 10-S

Prevents both sap stain and mold, in freshly cut hardwoods and softwoods

FPRS

Executive Officers

President
M. B. Christian, Tallulah, La.

President-Elect
R. H. Bescher, Pittsburgh, Pa.

Vice President
F. H. Kaufert, St. Paul, Minn.

Past President
L. J. Carr, Sacramento, Calif.

Executive Secretary
Frank J. Rovsek, Madison, Wis.

•

Regional Board Members

Southeast
E. S. Harrar, Durham, N. C.

South-Central
W. J. Eason, Memphis, Tenn.

Northeast
F. T. Parrish, Gardner, Mass.

North-Central
R. L. Hiller, Hartland, Wis.

Northwest
J. D. Ritchie, Tacoma, Wash.

Southwest
R. H. Berry, Burney, Calif.

•

Publications Committee

Chairman
Edward G. Locke, Madison, Wis.

•

Editorial Staff

Editor
Edward H. Roche, Madison, Wis.

Editorial Assistant
Ruth J. Gehred

THE FOREST PRODUCTS JOURNAL is published monthly by the Forest Products Research Society, P. O. Box 2010, University Station, Madison 5, Wisconsin. Entered as Second-Class Matter, April 1952 at the Post Office, at Madison, Wisconsin.

Annual subscription rate, $15.00; single copies $1.00, except October Yearbook Number, $4.00. Annual subscription rate is $11.25 with voting, associate, and supporting memberships in the Society. Remittances should be made payable to the Forest Products Research Society.

Correspondence on editorial matters should be addressed to the Editor, at the Executive Office. The Society is not responsible for views expressed in publications.

FOREST PRODUCTS JOURNAL

Vol. VI, No. 3 March, 1956

CONTENTS

Page

FPRS News-Digest ---------- 5–A, 29–A
Paul Bunyan Barbecue, Tour of Smoky Mountains to Highlight 10th National Meeting Entertainment ---------- 6–A
Abstracts of Papers, FPRS Tenth National Meeting ---------- 25–A
President's Column ---------- Moss B. Christian 11–A
FPRS Welcomes The Upson Co. As Newest Supporting Member ---------- 24–A

GLUES AND GLUING

Development of a Method for Rapid Laminating of Lumber without the Use of High-Frequency Heat ---------- G. G. Marra 97
Durability of Radio-Frequency Bonded Urea Resin Joints ---------- 19–A

SAWMILLING

Handbook for Small Sawmill Operators—Introduction ---------- F. C. Simmons and J. S. Bethel 105

FURNITURE MANUFACTURE

A Short System for Pro-Rating Direct Labor Costs in Furniture Plant Rough Mills ---------- J. W. Creighton 108
Production Control for Maximum Machine Efficiency ---------- R. F. Wilder 13–A

COMPOSITION BOARD

Significant Factors for Establishing a Particle Board or Hardboard Plant ---------- S. C. Rooney 110

WOOD PRESERVATION

The Effect of the Oil Carrier on the Performance of Pentachlorophenol-Treated Wood in Ground Contact Exposure ---------- F. J. Meyer and R. M. Gooch 117

SEASONING

Improved Utilization of Western Hardwoods by Modern Drying ---- H. H. Smith 121
Casehardening Stress Relief of Ponderosa Pine ---------- L. D. Winkel 124

PROPERTIES OF WOOD

Strength Properties of Plantation-Grown Slash Pine ---------- P. R. Kramer and R. L. Smith 129

EDUCATION

On-the-Job Orientation Training for Technical Personnel ---------- L. F. Maybach 14–A
Professional Development of Technical Personnel On the Job ---------- R. E. Baker 17–A

DEPARTMENTS

Book Review—Technology of Wood and Wood-Base Materials, Vol. II. Franz Kollman ---------- Reviewed by H. O. Fleischer 20–A
Around the World in Forest Products Research ---------- 21–A
Abstracts from Current World Literature ---------- 22–A
Index to Advertisers ---------- 32–A

IMPORTANT FPRS DATES

Spring 1956: Mid-South Section Plant Tour to Kirby Co., Lufkin, Texas

April 19–20: Northeast Section Meeting, Springfield, Mass.

April 26–27: Great Lakes Section Meeting, Manistee, Mich.

May 2–3: Midwest Section Meeting, Dubuque, Iowa

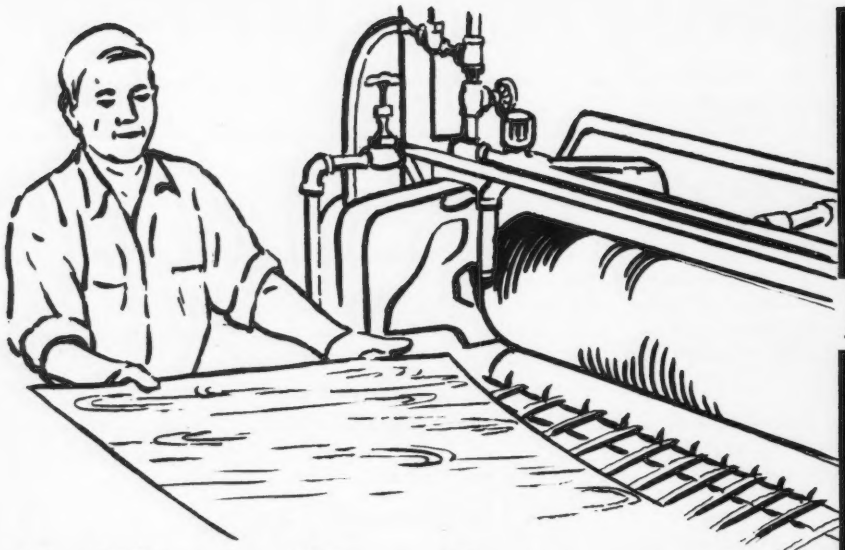
May: Ohio Valley Section Meeting, Jasper, Ind.

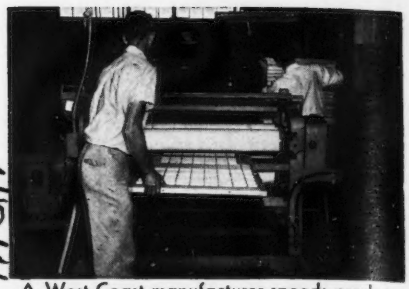
May 7–8: Pacific Northwest Section Meeting, Eugene, Ore.

June 4–7: Tenth National Meeting, Asheville, N. C.

Fall 1956: Mid-South Section Annual Meeting, Laurel, Miss.

Dec. 7–8: Florida–Georgia–Alabama Section Annual Meeting, Athens, Ga.

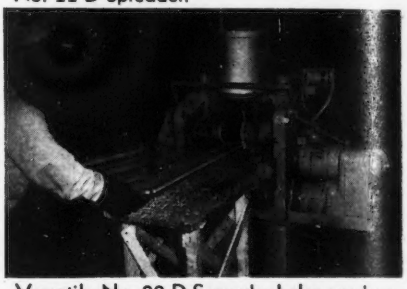




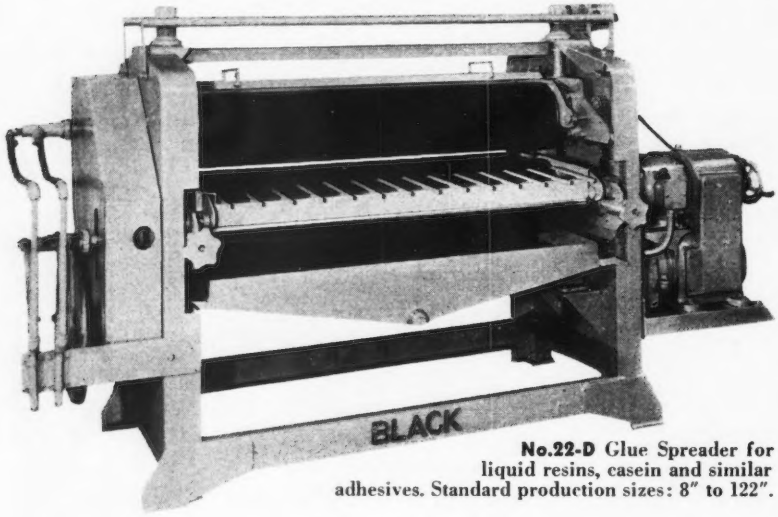
A West Coast manufacturer speeds production of hollow core flush doors with the No. 22-D, 50".

For glue testing and development work a leading glue manufacturer depends on the No. 22-D Spreader.

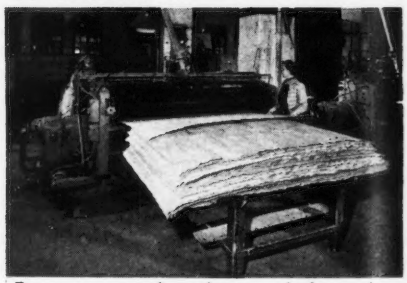
Brilliant New Successes in Gluing and Laminating



Versatile No. 22-D Spreader helps produce laminated beams and roof trusses at a California mill.



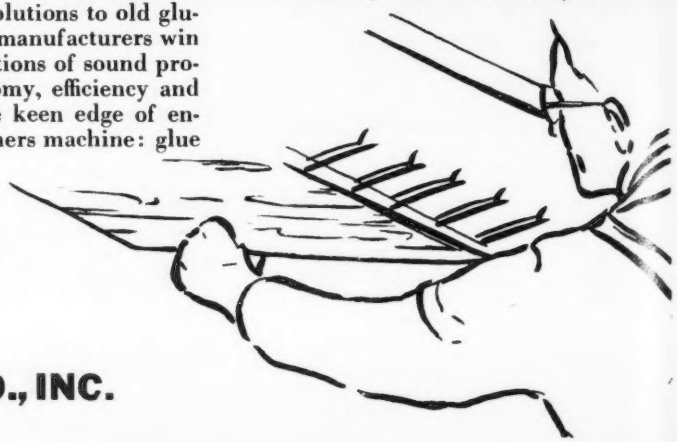
No.22-D Glue Spreader for liquid resins, casein and similar adhesives. Standard production sizes: 8" to 122".



Fast, economical production of plywood in a Finnish plant. The No. 22-D, of course.

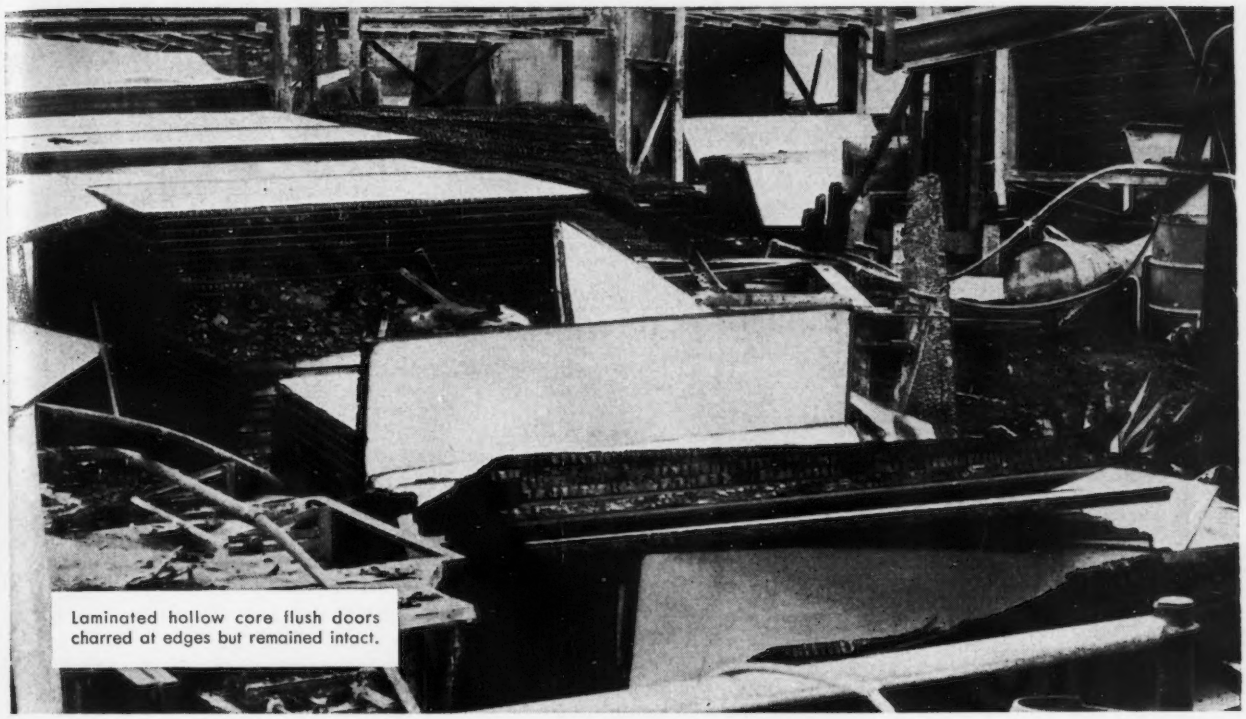
On production lines, in glue rooms and laboratories . . . Black Brothers Gluing and Laminating Equipment provides new solutions to old gluing and laminating problems. Helps cost-conscious manufacturers win new competitive markets, too, through new applications of sound production techniques. Preferred for its proven economy, efficiency and speed, the versatile No. 22-D Spreader reflects the keen edge of engineering skill incorporated into every Black Brothers machine: glue spreader, mixer, press or clamp.

Shouldn't you consider a Black Brothers installation? Write for our Supplement to Bulletin No. 11-A which gives construction details and specifications on the No. 22-D Glue Spreader.



THE BLACK BROTHERS CO., INC.

DEVASTATING FIRE



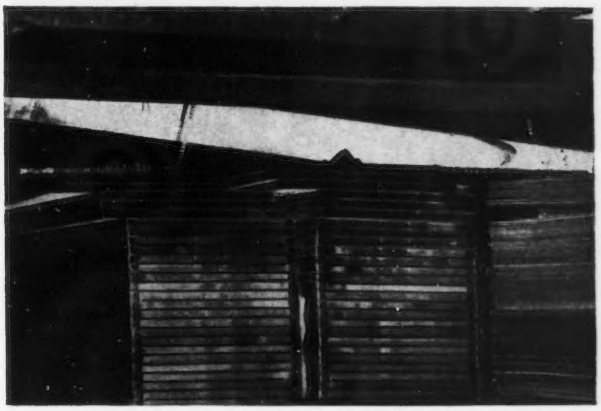
Laminated hollow core flush doors charred at edges but remained intact.

fails to part WOOD-LOK® 60R laminations

WOOD-LOK 60R resin glue resists heat! Any doubts? You're looking at the fire devastated plant of the Bay Sales Door Company of Tampa, Florida. When destroyed in mid-August, it was laminating 800 Philippine Mahogany hollow core flush doors a day. Despite the intense heat, WOOD-LOK 60R glue lines held. Laminations failed to part. Photographs were taken after seven days of rain that followed the fire. (Bay Sales modern new plant is now in full production.)

WOOD-LOK 60R is ready for use. No mixing. No heating. It laminates with amazing speed. Requires only a 20-30 minute press. Withstands machining in as little as 2 hours. No curing rooms are needed. Your plant can convert to continuous streamlined production with WOOD-LOK 60R. Investigate National's Kwik-Klamp Process which eliminates "I" beams and retaining clamps. Let one of our Wood-Working Specialists outline this faster method to you.

Bay Sales was laminating 800 doors a day before fire.



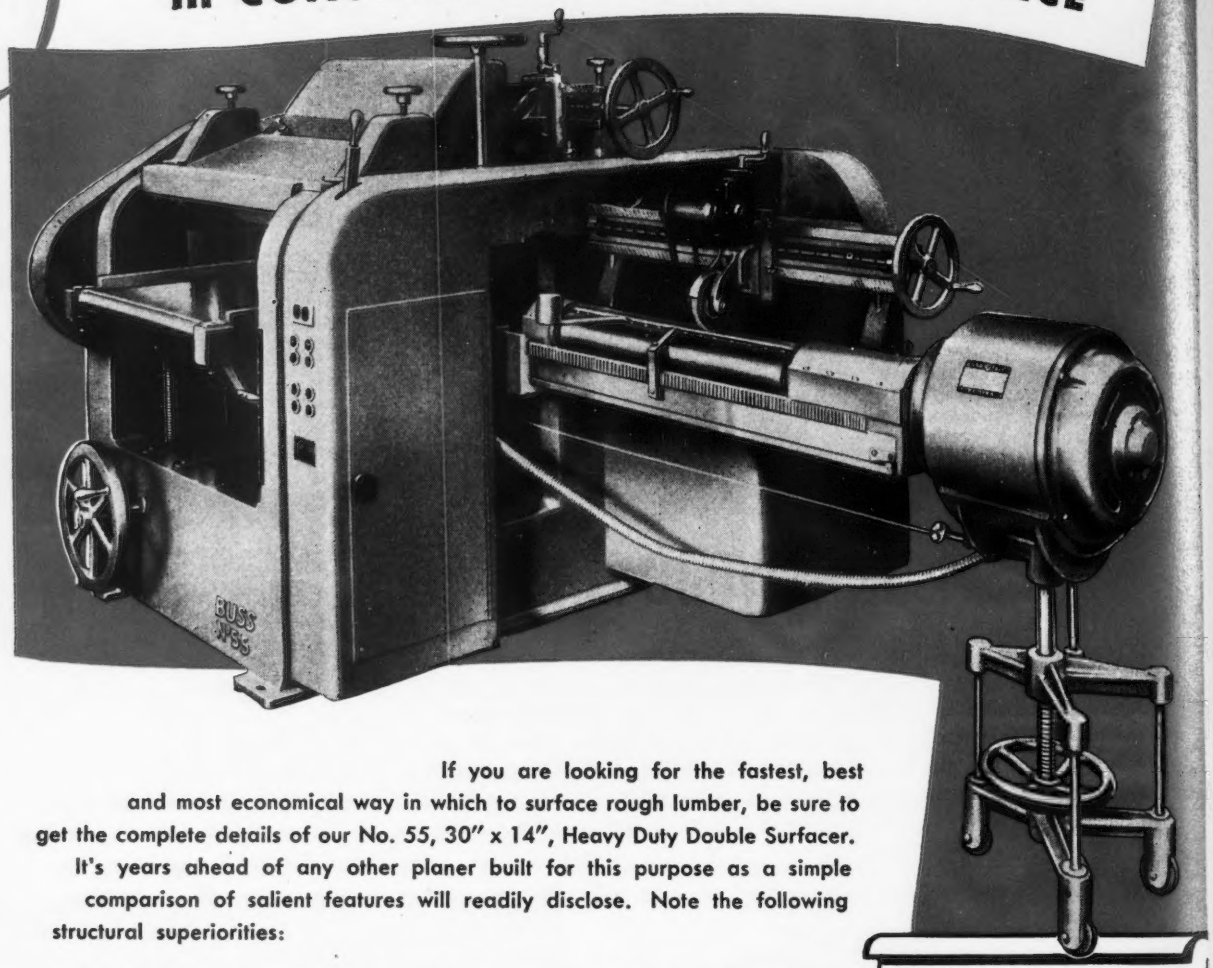
Flush doors resisted terrific heat build up under rafters.

RESYNS® National ADHESIVES

SPECIAL OFFER! Write for 5 gallons of WOOD-LOK 60R and a complimentary glue applicator—for joint or laminating operations—on a trial and approval basis.

NATIONAL ADHESIVES. Woodworking Department WD (Resin Division), 270 Madison Ave., New York 16 • 3641 So. Washtenaw Ave., Chicago 32 • 735 Battery St., San Francisco 11 • 1511-23 So. Main St., High Point, N. C.

for DOUBLE SURFACING ROUGH LUMBER the BUSS No. 55 is YEARS AHEAD in CONSTRUCTION and PERFORMANCE



If you are looking for the fastest, best and most economical way in which to surface rough lumber, be sure to get the complete details of our No. *55*, 30" x 14", Heavy Duty Double Surfacer. It's years ahead of any other planer built for this purpose as a simple comparison of salient features will readily disclose. Note the following structural superiorities:

1. Variable feed — from 30 to 175 ft. per minute. 2. Chromium plated beds and bars — for longer wear. 3. Heavy built-in grinders and jointers. 4. Anti-friction ball and roller bearings throughout. 5. Sectional feed roll and chipbreaker. 6. Large diameter cutterheads with high-speed TUNGSTEN knives for longer wear and smoother finish. 7. Completely motorized with push-button control. 8. Shearing Bar to prevent damage from loose knots. 9. ONE-SHOT lubrication for smooth running and insurance against neglected parts. Write for complete description. Ask for bulletin *55*.

FLOORING MILLS and KINDRED PLANTS

No. 55 is also available in 20-inch width with speed stepped up to 275 ft. per minute. This model has proved itself a "bear-cat" for Flooring Mills and similar operations. Let us tell you about it.

BUSS
SINCE 1862
MACHINE WORKS

PLANER SPECIALISTS EXCLUSIVELY

292 EIGHTH STREET
HOLLAND, MICHIGAN

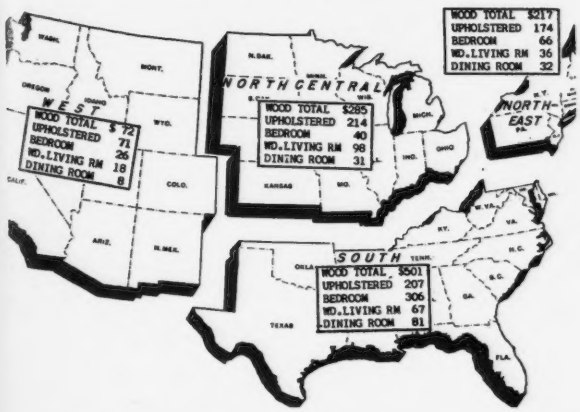
FPRS NEWS-DIGEST

Volume VI MARCH, 1956 Number 3

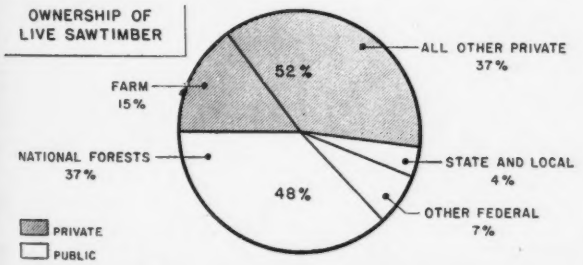
GRAPHIC TRENDS

Household Furniture Shipments—1953

(Millions of Dollars)



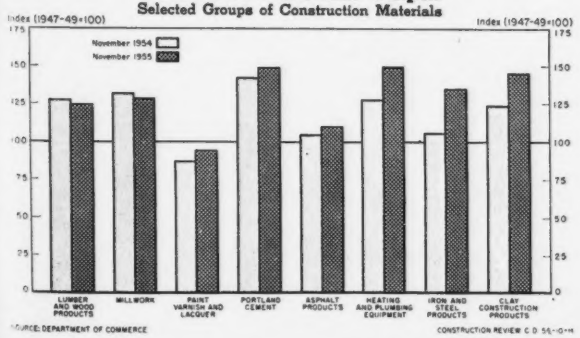
South shipped $501 million worth of wood furniture in 1953, according to above map by Southern Furniture Manufacturers's Assoc., based on figures by Bureau of Census. Shipments for other areas were: North Central, $285 million; Northeast, $217 million; and West, $72 million.



More than half of present sawtimber supply is privately owned, according to preliminary draft of Timber Resource Review by U. S. Forest Service. In both North and South, about 90 per cent is privately owned; in West and Coastal Alaska, half is in national forests and total of 60 per cent is publicly owned.

Indexes of Materials Output

Selected Groups of Construction Materials



BUSINESS OUTLOOK

NATION'S TIMBER NEEDS are expected to be so high by year 2000 that timber growth will have to be 70 to 120 per cent greater than now, according to preliminary draft of Forest Service's Timber Resource Review. Adding a 15 per cent contingency margin, TRR says U. S. in year 2000 may be using 12.6 billion board feet more sawtimber than is being cut. In analysis of report for Forest Industries Council, Dr. J. A. Zivnuska, economist, suggests removing contingency margin, says revised estimate would then show 8.5 billion board feet excess of growth over cut. Warning against complacency, he said acceleration of present trends in forestry and utilization is necessary to take full advantage of opportunities.

WHAT THE USER WANTS is underlying theme of several technical sessions at 10th FPRS National Meeting June 4-7 in Asheville, in accord with current business trend. "In today's keenly competitive atmosphere, thinking and planning must start at the consumption end of the stream of motions, rather than the production end," says Charles Mortimer, President, General Foods Corp. "Today's successful product is likely to start as a consumer-use specification."

—Vital Speeches of Month

DOUBLED CHIP PRODUCTION frow sawmill wastes in a year was revealed in survey of 59 Southern mills. At close of '55, chips were being produced at rate of 371,000 equivalent cords, compared to '54 rate of 175,000 cords. The region is far ahead of scheduled progress toward 1960 goal of 500,000 cords estimated in 1954 Weyerhaeuser study.

—Pulpwood Production Magazine

Paul Bunyan Barbecue, Tour of Smoky Mountains To Highlight 10th National Meeting Entertainment

An old-fashioned southern style barbecue is one of many attractions scheduled at the 10th National Meeting of FPRS June 4–7 in Asheville, N. C. The event is sponsored by forest products industry suppliers, who invite registrants and their families to an afternoon and evening of sightseeing in the Smoky Mountains, climaxed by the Paul Bunyan Barbecue.

Busses will leave Asheville after lunch on June 6 for the Qualla Indian Reservation at Cherokee, N. C. The caravan will travel via U. S. Highway 19 past the sparkling waters of Lake Junaluska, site of the Methodist Summer Assembly, and over the mountains to Cherokee, center of the Qualla Indian Reservation and seat of government of the 3,500 members of the Eastern Band of Cherokee Indians.

Cherokee is a picturesque village composed chiefly of shops where the Indians display their crafts in weaving, pottery, basket-making, and wood carving. A visit will also be made to Oconaluftee Village, replica of a 200-year-old Cherokee Indian village, with its stockade, town-house, sweat-house, and wigwams. Here the Indians tell the story of ancient mountain life in customs and dress in the drama, "Unto These Hills."

A short distance from Cherokee, at the Oconaluftee Ranger Station, a visit will be made to the Pioneer Exhibit, a group of authentic log buildings containing the implements and utensils of the pioneer mountaineer era of the Southern Appalachians. Tools, materials, and photos covering nearly two centuries of life in the southern highlands are displayed here. Pioneer exhibits include tanning and shoe making, blacksmithing, weaving and garments, period-room display, and a large display of rifles.

Shortly before sundown, the caravan will travel back through the mountains through Soco Gap, and turn off on a newly constructed section of the Blue Ridge Parkway to Great Smoky Mountains National Park. By way of Mile High Overlook, regarded as the most spectacular view of the Great Smokies, FPRS registrants and guests will travel to Heintooga Bald Overlook and picnic area. A southern style barbecue and evening entertainment will climax the afternoon of sightseeing.

Great Smoky Mountains National Park is richly endowed by nature, having over 1700 species of plant life, 200 species of birds, 80 kinds of fish, and some 52 species of fur-bearing animals. The park has six large recreational areas and 650 miles of trails in a 500-square-mile area.

Southern-style barbecue will be sponsored by industry suppliers.

The Paul Bunyan Barbecue and sightseeing excursion is just one of many attractions at the National Meeting. In addition to the 14 Technical Sessions and outstanding "FPRS Suppliers Exhibit," entertainment will also include the traditional "Annual FPRS Party," a full ladies program, and an outdoor spectacle on Smoky Mountain life and times, "Tight Britches."

Barbecue Sponsors

The cost of the Paul Bunyan Barbecue and sightseeing trip is largely underwritten by forest products industry suppliers. A partial list of these sponsors to date, largely adhesive manufacturers, sand paper and abrasive manufacturers, and machinery manufacturers, includes: The Coe Manufacturing Co.; Wilco Machine Works; Kennametal, Inc.; Standard Dry Kiln Co.; Catalin Corporation of America; Raybond Electronics; Kirk & Blum Manufacturing Co.; Soderhamn Machine Manufacturing Co.; Nelsonite Chemical Products, Inc.; Yates-American Machine Co.; American Manufacturing Co.; Southern Screw Co.; Carborundum Co.; Lilly Co.; Miller-Hofft Co.; Bauer Bros. Co.; National Casein of New Jersey; Chapman Chemical Co.; Synvar Corp.; Hitchcock Publishing Co.; Auto-Soler Co.; Perkins Glue Co.; Borden Co.; DeLuxe Saw & Tool Co.; Jenkins Woodworking Machinery Div., Curt G. Joa, Inc.; Masonite Corp.; S. H. Smith Co.; Pacific Lumber Co.; Henry Disston Division, H. K. Porter Co., Inc.

See Preview of
National Meeting Papers
Pages 25-A–28-A

FPRS Suppliers Exhibit Nears Complete Sellout

The following have reserved exhibit space as of March 26:

Adamson–United Co.
Bahnson Co.
Balsa Ecuador Lumber Co.
Bay Chem. Div., Morton Salt Co.
Binks Manufacturing Co.
Borden Co.
Bramco, Inc.
Carboloy Div., General Electric Co.
Carolina Forest Products
Catalin Corp.
Cellu-Products Co.
Chipcraft, Inc.
Cleworth Publishing Co.
Dean Co.
Decar Plastics Co.
Deluxe Saw & Tool Co.
Dependable Machine Co.
Drexel Co.
DuPont Co.
Durez Chemicals & Plastics
Franklin Glue Co.
Hardwood Corp. of America
Heil Co.
Hoe Co.
Jenkins Div., Curt G. Joa, Inc.
Kennametal, Inc.
Lilly Co.
Marietta Paint & Color Co.
Masonite Corp.
Mall Tool Co.
W. F. Meyers Co.
Miller–Hofft Co.
Moore Dry Kiln Co.
National Adhesives
National Casein Co.
Norman & Lambert Co.
Onsrud Machine Works
Perkins Glue Co.
Power Wire Products
Raybond Electronics
Reichhold Chemicals, Inc.
Allen T. Sheppard Co.
Simonds Saw & Steel
S. H. Smith Co.
Spotnails, Inc.
Standard Dry Kiln Co.
Tri-State Co.
U. S. Plywood Corp.
Wel-Dri Co.
Weyerhaeuser Sales Co.
Wilco Machine Works
Williams–Brownell Co.
Woodwelder Co.

Asheville Welcomes You To FPRS National Meeting June 4–7

View of Smoky Mountains from Heintooga Bald Overlook, site of Paul Bunyan Barbecue.

Ocunaluftee Village, replica of 200-year-old Cherokee Indian Village, will be visited enroute to barbecue.

FPRS National Meeting registrants have choice of several excellent hotels. George Vanderbilt, Battery Park, and Asheville–Biltmore are among those near Municipal Auditorium, meeting headquarters.

Record 230 Attend Pacific Northwest Section Annual Meeting

Part of record crowd (left) which attended recent Annual Meeting of Pacific Northwest Section. Speakers included (right): C. F. Craig, J. Knapp, R. A. Currier, and H. W. Berry.

New officers of Pacific Northwest Section include, left to right: J. R. Billinger, Chairman; J. H. Syme, Secretary-Treasurer; H. R. Evans, Past Chairman; and R. W. Wellwood, Vice-Chairman.

Automatic veneer drier feeder at Long-Bell Lumber Co., visited on plant tour during Pacific Northwest Section meeting.

Northeast Section Meeting Program Plans Announced

Technical sessions on "What Makes Glue Hold" and "Modern Adhesive-Based Products" will be features of the Northeast Section Spring Meeting April 19 and 20 at Hotel Sheraton-Kimball, Springfield, Mass. Four informal idea exchange sessions are also planned, according to Section Vice-Chairman Don K. Saunders, Program Chairman.

Speakers and topics will include: W. T. Nearn, Factors Affecting Quality of an Epoxy Resin Wood-to-Wood Bond; Henry Brown, Charcoal; D. Brouse, The Ideal Glue; Allen Midyette, Molded Products Processing; John Crafton, Extruded Chipcore Board; H. C. L. Miller, Flat Press Process; Alec Fiskin, Flat Press Particle Board; Wayne Lewis, Particle Board Testing; Carl A. Rishell, European Particle Boards; J. Coufal, Gluing and Fabricating Flush Doors; A. G. Whyte and Warren Poitras, Paper- and Fabric-Backed Veneers; J. E. Gurvitch, Compreg; F. J. Heger, Jr., Strength Properties of Plywood and Their Effect on Structural Design in Building Construction.

Technical session moderators will be Frank T. Parrish, J. A. Hauter, and Donald Pierce. Idea exchange sessions on merchandising and marketing, research, machining, and education and employment will be led by H. Seidel, J. M. Yavorsky, R. J. Hoyle, Jr., and N. A. Norton.

Section Chairman Charles R. Lockard will be toastmaster for the annual banquet and present annual student awards. Principal speaker will be Paul Cohen, Monsanto Chemical Co., who will discuss his firm's contributions to the forest products industry.

Plant visits being arranged include a tour of A. G. Spalding & Sons, Chicopee, Mass.

Utilization of Hardwoods Theme of Great Lake Section Meeting

"Utilization of Michigan Hardwoods" will be the theme of the Spring Meeting of the Great Lakes Section, April 26–27 in Manistee, Mich.

The tentative technical program includes papers on production of hardwood lumber and its manufacture into lab equipment, use of hardwood in laminates, use of hardwoods in manufacture of furniture packaging materials, pre-fabricated log cabins, chipcore manufacture from Michigan hardwoods, hardwood veneer manufacture, and the manufacture of wood boats. Field trips are scheduled to the American Boxboard Co. and Century Boat Co.

Candidates Announced for FPRS National and Regional Posts

Candidates for national and regional offices of FPRS have been announced by the 1956 National Nominating Committee and two regional committees. Elections will be by mail ballot, with results announced at the Tenth National Meeting June 4–7 in Asheville, N. C.

Ralph H. Bescher, District Manager, Wood Preserving Division, Koppers Co., Inc., Pittsburgh, Pa., currently President-Elect, automatically becomes President in June. He will succeed Moss B. Christian, Chicago Mill and Lumber Co., Tallulah, La., who will remain on the Executive Board as Past President.

The 1956–57 candidates are:

For President-Elect—Frank H. Kaufert, School of Forestry, U. of Minnesota, St. Paul, Minn.

For Vice-President—W. Jeter Eason, Nickey Brothers, Inc., Memphis, Tenn.; or J. A. Hall, U. S. Forest Products Laboratory, Madison, Wis.

For Southeast Regional Board Member (3-year term)—Carl L. Brice, Brice Lumber Co., Archer, Fla.; or W. L. Irwin, Poinsett Lumber and Manufacturing Co., Pickens, S. C.

For South-Central Regional Board Member (3-year term)—W. R. Warner, Southern Lumber Co., Warren, Ark.

For 1957 National Nominating Committee (4 to be elected)—K. G. Fensom, Forest Products Laboratories of Canada; E. G. Locke, U. S. Forest Products Lab.; C. C. Heritage, consultant; F. E. Dickinson, U. of California; C. R. Lockard, Northeastern Forest Experiment Station; W. J. Tomford, James E. Stark Co.; G. A. Garratt, Yale University; and W. R. Smith, Southeastern Forest Experiment Station.

The Constitution of FPRS provides that: "Voting shall not be restricted to the names submitted. 25 voting members may file with the Executive Secretary, within 30 days after notification of the action of the nominating committees, the name of an eligible candidate for any elective office for which they are entitled to vote. The name of such candidate shall be placed on the ballot. Further, any voting member may vote for any eligible member of his own choice for any elective office by inserting the member's name on the ballot."

On the Cover

Host Committee for National Meeting includes, front row: J. S. Bethel, Exhibits; Mrs. W. R. Smith, Ladies Program; G. M. Hill, Finances; W. L. Irwin, Entertainment; back row: E. S. Harrar, General Chairman; H. J. Loughead, Publicity; J. B. Hayward, Paul Bunyan Barbecue; W. R. Smith, Asheville Arrangements.

Midwest Section Announces Spring Meeting Plans

The modular system of home construction and its influence on millwork, furniture, and dimension lumber will be the theme of the opening day program at the spring meeting of the Midwest Section May 2 and 3 in Dubuque, Iowa. Three speakers are scheduled for the second day technical session, with papers to include water repellents and fungus treatments for the millwork industry, and humidification control in the factory. J. J. Allegretti is Program Chairman and Harvey Gill is Chairman of local arrangements.

Pacific Northwest Section Schedules Meeting in Eugene

Pulping and sawmilling will be the theme of the Spring Meeting of the Pacific Northwest Section May 7–8 at Hotel Eugene, Eugene, Ore., according to Vice-Chairman R. W. Wellwood.

The tentative program includes: Potential for Mill Residues in Pulp Industry, J. B. Grantham; Distribution of Fungicidal Extractives in Western Red Cedar Heartwood, H. MacLean and J. A. F. Gardner; Pulping of Western Red Alder; Economics of Operating a 100-Ton Kraft Mill from Waste Wood; The Right Saw for the Job, P. S. Quelch; Automation in the Sawmill Industry, S. M. Batori; and the Temple-Bovay Automatic Sorter.

Field trips are scheduled to Kraft manufacturing facilities of Weyerhaeuser Timber Co., Booth-Kelly Lumber Co., and the particle board plant of Clear Fir Sales Co.

Dr. J. R. Stillinger was elected Chairman at the recent annual meeting in Longview, Wash. (See Feb. Journal, p. 11-A). Other new officers are: R. W. Wellwood, Vice-Chairman; J. H. Syme, Secretary-Treasurer; and G. E. Tower, Trustee. Other trustees are: J. E. Lodewick and Past Chairman H. R. Evans. Perry Culp was appointed Publicity Chairman.

The Section pledged $500 to the National Executive Office Building fund during the annual business meeting. Membership Chairman Earl McCarthy reported current Section membership was 455. The members also passed a resolution expressing regret at the untimely death of T. J. Heppenstall and extending condolences to his family. It was announced that a joint meeting with the Inland Empire Section will be held in early September.

FOREST PRODUCT ENGINEERING

BOARD MILLS
PLYWOOD MILLS
LUMBER MILLS

SURVEYS REPORTS
DESIGN OPERATION

COLUMBIA ENGINEERING COMPANY

CONSULTING INDUSTRIAL ENGINEERS

209 CREES BUILDING
CORVALLIS, ORE.

16 EAST HASTINGS STREET
VANCOUVER 4, B. C.

It's Good Public Relations

TO BE A SPONSOR AT FPRS 5TH ANNUAL "PAUL BUNYAN" ACTIVITIES
In Conjunction with FPRS 10th National Meeting, Asheville, N. C., June 4–7

For Your Customers Who Are Registered

★ A delightful afternoon and evening of sightseeing as your guests in the Great Smokies, climaxed by a real Southern Barbecue at Heintooga Bald Overlook picnic area.

★ An evening of top-flight, professional entertainment during the annual "FPRS Party."

For Your Company

★ Your company name listed in over 1,000 Official Programs.

★ Your company name prominently displayed or announced both at the Barbecue and throughout the meeting.

★ The satisfaction of joining other firms in supporting a truly outstanding social event in the wood-using industries.

SPONSOR COST, $50

(mail check to Jack Hayward)

For reservation or further information, write:

JOHN B. HAYWARD
Chairman, Paul Bunyan Activities
500 Sunset Drive
High Point, North Carolina

Extra durable bonds with

LAUXITE* 326

Monsanto's one-package melamine-urea adhesive upgrades skins and doors with outstanding dry strength and high water-resistance!

MONSANTO

*LAUXITE: REG. U. S. PAT. OFF.

Lauxite 326 is specially formulated by Monsanto for hot press gluing of exterior work. This dustless, water-soluble powder assures a lasting bond with a high degree of water-resistance.

It is easy to prepare – add only water. Its working life is at least 72 hours at 75°F. Its cure time is fast. It has little formaldehyde odor. Its coverage is high – 25-35 pounds for 1,000-square feet of single glue line.

The superior washability of Lauxite 326 makes equipment cleaning easy. Its light-color glue lines help to eliminate staining problems on thin veneers.

Let us tell you how Lauxite 326 can be economically formulated to satisfy your extreme and intermediate durability requirements. Write today for test samples and data sheets. Monsanto Chemical Company, Plastics Division, Room 463, Springfield 2, Mass.

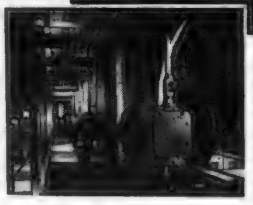
Crawford of Jamestown

CRAWFORD FURNITURE MANUFACTURING CORPORATION • JAMESTOWN, NEW YORK

CHOOSES Standard PREFABRICATED DRY KILNS

And no wonder! Compared with a good masonry building, the *Standard Prefabricated Dry Kiln* cuts steam radiation losses 50% or more . . . *resulting in tremendous fuel cost savings.*

To produce uniformly-dry lumber, efficiently and economically, take a tip from the folks at Crawford. Install *Standard Prefab Kilns* now. They can be *completely* installed in any size—from a small research kiln to a large production unit—in only a few days!



Here is the *Standard Prefabricated Dry Kiln* installation at the modern Crawford factory in New Bethlehem, Pa. The sturdy building is constructed of vapor-proof, rust-proof, heavily-insulated aluminum panels which require *no maintenance.* Entire building can be quickly and easily moved to a different location whenever desired.

View of fan chamber showing *Standard's* cross-circulating, direct-driven internal fan units, properly placed to face side wall:. Each ball-bearing motor is glass and silicone-insulated to withstand temperatures up to 356° F. and humidities up to 100%. Note fin pipe heating system.

Write Today for Free, Illustrated Standard Catalog

Manufacturers of Internal Fan Kilns

STANDARD

Engineers and Manufacturers Since 1887

DRY KILN COMPANY

P. O. BOX 5708....INDIANAPOLIS 21; IND.

BRANCH OFFICE: REDMAN ENGINEERING SERVICE • HIGH POINT, N. C.

Open Door to Brighter Future[1]

TORONTO, ONT.—I was happy, indeed, to have the pleasure of attending the Eastern Canadian Section Meeting and of seeing old friends again and making new ones with our friendly neighbors to the north. I learned only last year, through an article in National Geographic Magazine, that 12 years before Lewis & Clark blazed their historic trail across our Northwest, Canada's fur trader Alexander Mackenzie painted his name in bear grease on the rugged coast of British Columbia and thanked God for bringing him safely across the vast country.

M. B. Christian

One of the most pleasant weeks I've ever spent was on the beautiful Lake of the Woods in the western part of Ontario. The beautiful scenery, cool climate, and excellent fishing was enhanced by the simple kindness and friendly welcome we received from the Canadian people.

This was the fourth Sectional meeting I've attended since becoming National President. I believe the quality of these meetings within our 13 geographic sections will largely determine the quality of service our Society can render to the forest products industry. To me, our publication, the FOREST PRODUCTS JOURNAL, is our greatest asset and without these meetings we could not have the excellent publication of which we are so proud. Papers presented at this meeting, when published, serve about 8,000 people, for although our Journal has a circulation of 3,500 copies, surveys have shown an average of 2½ to 3 people read each issue. As you know, we now publish our Journal on a monthly basis which means that timely papers will reach the readers much faster.

In the past seven years, our membership has more than doubled including the development of your Section in Canada and members in 39 foreign countries. Recently there has been a request for a new Section in the Philippine Islands, and we have had some expression of interest for a similar chapter in England. The main objective of our organization is to promote the exchange of ideas which will open doors to a brighter future for our forest products industry.

Our 1956 National Meeting will be held in the heart of the Smoky Mountains June 4–7 at Asheville, N. C. The tentative technical program consists of 14 sessions, a greater variety than we have ever had at a National Meeting.

Some of the titles and themes were of special interest to me. For instance, the theme for a Composition Board Session is "What the User Wants". I believe that many of our successful products of tomorrow will be developed by learning the consumer's specification rather than learning the producer's specification and I am happy to see this approach by the Composition Board Committee.

Another timely paper will deal with laminating 2 x 4's without high-frequency heat. The Logging and Milling theme is "More Complete Utilization", and will include papers on automatic sawmill operation and waste utilization. These and many more interesting developments in our industry will be discussed at Asheville.

I shall look forward to seeing you at the 10th National Meeting in June.

MOSS B. CHRISTIAN, *President*

[1] Excerpts from address at annual meeting of FPRS Eastern Canadian Section, March 1–2, 1956, in Toronto, Ont.

how a Borden adhesive works magic with wood waste

This neat trick not only conserves forest reserves . . . it saves important money for the lumberman, the woodworker, and the buyer of many wood products.

Here's what happens. You take parts of the tree and cut-lumber that were formerly considered waste. You grind it with a newly devised machine into chips. Then you bond it under heat and pressure—with a special Borden adhesive—to form a revolutionary new structural board with unusual strength, rigidity, dimensional stability and resistance to warping. It can be drilled, sawed and nailed the same as lumber.

Even now this economical new waste board is widely used for the construction of furniture, doors, interior panels, flooring underlay, and partitioning. More widespread use is predicted as the result of experimental projects now under way . . . because this Borden-bonded board can actually save up to 40% of the cost of regular lumber stock for which it is substituted.

From the conservation standpoint . . . it has been reported that while as little as 12% of a log is utilized when sawed, up to 67% can be used if it is made into wood waste board.

This special adhesive binder developed for wood waste board is another example of industry's adhesive problems solved by Borden experts. So whether *your* adhesive problem lies in the field of woodworking, boats, packaging or labeling . . . it will pay you to consult a Borden specialist about the right binder for the job. Write without obligation to The Borden Company, Chemical Division, Dept. PJ-36, 350 Madison Ave., New York 17, N. Y.

ADHESIVES * CASEIN * INDUSTRIAL CHEMICALS
RESIN * POLYMERS * MOLDING COMPOUNDS

T. B. C.

THE Borden COMPANY
CHEMICAL DIVISION

FPRS Forest Products Journal

Vol. VI, No. 3
March, 1956

Development of a Method for Rapid Laminating of Lumber without the Use of High-Frequency Heat[1]

GEORGE G. MARRA

Head, Wood Technology Section, Division of Industrial Research, Washington State Institute of Technology, Pullman, Wash.

Laminated lumber with typical exterior-type adhesive bonds is produced without high-frequency heat and with pressure time reduced to seconds. The basic principle consists of preheating surfaces to be laminated, applying phenolic resin or resorcinol-phenol combination, and pressing. Although the process was developed for laminated 2 x 4's, press times for larger beams would be the same as two-member assemblies and application of the method to such products as laminated beams for home construction, with marked cost reductions, is an imminent possibility.

Preface

THE RESEARCH DESCRIBED in this report was undertaken at the request of, and sponsored by, Potlatch Forests, Inc., Lewiston, Idaho. Much of the work was carried on cooperatively with the Research Department at Potlatch Forests. At their request, the results of the research were presented at a meeting of the Inland Empire Section of the Forest Products Research Society on Jan. 13, 1956, in Spokane, Wash. Their permission to make the information available to the public is appreciated by the State College of Washington. It is considered a tangible indication of Potlatch Forests' concern for the general welfare of the wood industry as a whole.

Considering the untried character of the basic principles involved in this research, the incubation period in the laboratory was remarkably short—less than a year transpired between conception of the idea and a successful pilot-plant operation on laminated 2 x 4's. The rapidity with which the pilot plant was authorized, designed, and placed in operation is a tribute to Potlatch Forests' management and engineers. To the research worker, it presents a form of recompense unmatched even in the pay envelope.

The staff of the Division of Industrial Research is indebted to Potlatch Forests, Inc., for this opportunity to share in a significant development for the lumber industry. Particular acknowledgment is made of the discerning guidance of Dr. H. B. McKean, Director of Research at Potlatch Forests, and of the meticulous attention to research details displayed by John W. Smith, Potlatch Research Department, who coordinated the project and carried on to the successful operation of the pilot plant.

[1] Presented at meeting of Inland Empire Section, FPRS, Jan. 12–13, 1955, in Spokane, Wash.

The Author: George G. Marra holds B.S. and M.S. from New York State College of Forestry, Ph.D. from Duke U. During World War II, he served as Chief, Wood Unit, Procurement Div., U.S. Air Force, later became Civilian Chief, Packaging Branch, Wright–Patterson Field, Dayton, Ohio. Marra was associate professor at West Virginia U. from 1947–51. A charter member of FPRS, he is Chairman of Wood Committee.

Historical Background

The technology of glues and gluing has made astounding progress during the last 25 years, much to the enrichment of the wood industries and all others economically related to these industries. The path of progress has at times been somewhat tortuous, particularly in the gluing of solid wood, but even now the item of cost still renders some operations prohibitive or elevates the products to the category of luxuries. Progress in reduction of costs, unfortunately, has not kept pace with progress in the improvement of bond quality.

Bonds more durable than the wood was a goal long sought and finally achieved to a superlative degree with the development and use of phenolic adhesives about 1930. These adhesives with their water-proof, boil-proof bonds, however, required high temperatures to cure, and not until the development of massive hot presses could the superior properties of these glues be taken advantage of in the large-scale manufacture of plywood.

These advantages were denied solid lumber products, such as laminated beams, because of the impracticability of forcing heat through any substantial thickness of wood. The advent of high-frequency heating quickly provided an answer to this difficulty, and the technique soon went on to greater glory in accelerating many types of gluing operations. The principal difficulty again was the high cost of the equipment for producing this type of heat and the high cost of operation.

The penalty of high-cost pressing and heating equipment was eased to a large extent during the 1940's with the development of resorcinol adhesives. These new glues could be made to cure at room temperature and provide all the other advantages of phenolic glues. But the penalty now took a different form. The glue itself was more costly; even today the cost of phenol-resorcinol glues is about five times that of the phenols on a ready-to-use basis. In addition, the glue required a long time to cure under pressure unless heat was added, normally about 4 to 8 hours under average room conditions. This is expensive time.

The problem in broad aspect, therefore, was to find ways of compromising these facts so that high-quality bonds in laminated lumber products could be achieved by low-cost methods. The development of one such method is described in this report, showing also a partial solution to the problem of low-quality lumber at a sawmill.

Fig. 1.—Random pairing of No. 4 common stock showing how mismatching of defects contributes to high quality of laminated 2 x 4's.

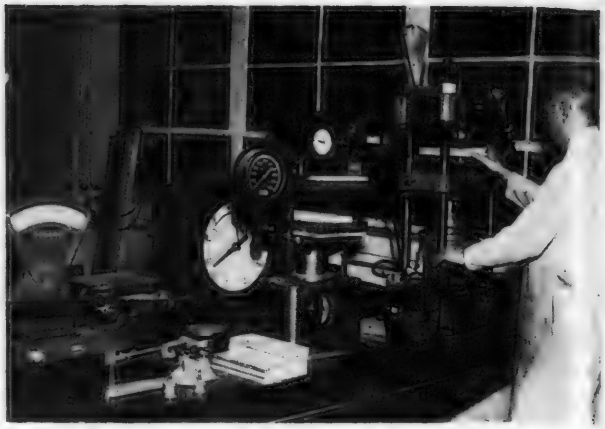


Fig. 3.—Two-press set-up for preliminary experiments on single preheat laminating.

Introduction to Problem

In August 1954, Potlatch Forests, Inc., Lewiston, Idaho, conceived the idea of laminating hard-to-sell 1 x 4's to produce 2 x 4's which were in greater demand. In such a process, an increase in quality is obtained due to the random mismatching of defects, such as knots and splits (Fig. 1) and to the randomization of forces which tend to produce warp in solid pieces of the same size. There is also a grade step-up due to thickness, knots of equivalent size and frequency being less damaging grade-wise in 8/4 stock than in 4/4.

Two requirements for an acceptable product and a successful process were stipulated at the outset. These were an exterior type or boil-proof bond between the members, and a high-speed, low-cost gluing operation which would maintain the total cost of gluing between $10 and $20 per 1000 bd. ft.

The first of these requirements called for the use of a phenol or a resorcinol resin, or a combination of these resins, in order to insure a bond of the proper quality.

The second requirement called for a very short time under pressure as well as a low glue cost. In the gluing operation, the major item of equipment is the press, and it usually represents the bottleneck in production. Hence the focus of the problem was a drastic abbreviation of the time cycle under pressure. Attendant problems of high-speed mechanical handling of the entire operation were also anticipated.

Two methods of accomplishing the abbreviation in press cycle were proposed. One method involved the use of high-frequency heating in a parallel-field application. Multiple loads seemed to offer some possibility of compensating for the high cost of the equipment. This approach later was abandoned because of the lack of adaptability of the equipment already on hand at Potlatch.

The second proposed method involved storing heat in the surfaces of the members to be glued as a first step, this heat later being available to effect a rapid cure of the resin. This method had a number of advantages, but introduced several secondary problems which formed the basis of the research reported here.

Preliminary Experiments

The first experiments with the preheating principle sought only to demonstrate that heat sufficient to cure an adhesive could be temporarily stored in one member while an unheated contacting member received the adhesive mixture. The wood consisted of kiln-dried, edge-grain Douglas-fir of higher than average density. This material was chosen in order to insure the highest possible stress on the glue joint at the time of testing the results of the bonding action. Work with typical No. 4 common stock was reserved for a later stage in the research.

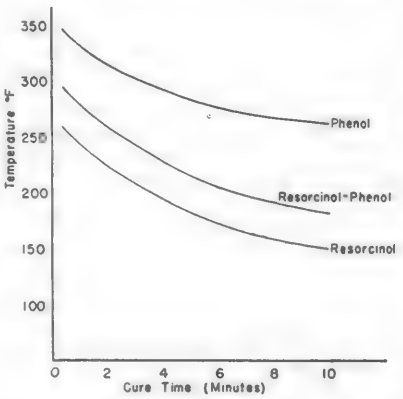


Fig. 2.—Time-temperature relationships for several boil-proof adhesive types.

The adhesive used was a phenol-resorcinol combination which, according to the manufacturer, had curing characteristics enabling it to cure in 4 to 6 hours at 85° F. and in 2 minutes at 250° F. (Fig. 2). Projected further, this information indicated the possibility of curing the resin completely in less than a minute at 350° F.

It was reasoned also that complete cure under pressure was not a necessary requirement for the bonding operation. Rather, a degree of cure was needed which would develop sufficient strength to hold the members in intimate proximity while the reaction proceeded to completion under the accelerating influence of the stored heat.

For these experiments the wood was cut into billets 3 inches x 10 inches, which were assembled in matched pairs. The equipment set-up (Fig. 3) consisted essentially of two presses, one used to preheat and the other to receive the two-piece assembly and apply pressure while the adhesive underwent the thermal reaction involved in curing. The adhesive, mixed in accordance with the manufacturer's recommendations, was spread by brush at the rate of about 50 pounds per 1000 square feet of glue line.

The principal factors which could be varied in this operation were: preheat temperature, preheat time, open assembly time, closed assembly time, pressure, and pressure time.

Initial screening of the possible combinations of variables which could lead to a successful operation had esta-

lished a range for each of these factors. Optimum *preheat temperatures* were believed to lie in the range of 300° F. to 400° F. *Preheat times* were from 2 to 10 minutes. *Open assembly time* was considered not critical, but it was believed desirable that this interval be below 20 minutes in order to reduce complications in production operations. *Closed assembly time* was believed at first to be extremely critical because of the possibility of precure of the resin; consequently this factor was held as near to zero time as possible. Later in this development, closed assembly time and attendant precure were found to be not as damaging as at first supposed, and the permissible latitudes discovered for this factor could very likely have been one of the keys to the success of the project.

Pressure, to a certain extent, is an item of cost, and it was considered essential that it be kept as low as possible, optimum presures probably lying in the range of 100 to 200 pounds per square inch. *Pressure time* is a factor which not only has a vital influence on bond quality, but also most directly controls rate of production, A range considered reasonable for this factor was 30 to 90 seconds under full pressure.

Adhesive spread could also be varied, but this factor was kept constant at as low a rate as possible in order to reduce adhesive costs to a minimum and also to reduce the cooling effect of any adhesive not required for optimum bonding action. The presence of a slight squeeze-out was considered as an indication of adequate spread.

The initial experiments were conducted at the midpoints of the ranges given above for the pertinent variables. With resorcinol-phenol resins, some open assembly time before applying pressure is a requirement for normal gluing. This step permits the adhesive to lose some of its volatiles and develop "tack" so that it cannot migrate away from the joint area when pressure is applied. In a hot application, an extended open assembly time was considered highly important in order to counteract the effect of heat in temporarily lowering the viscosity of the resin which, in turn, would permit escape of the resin from the joint area. Continued heating, of course, brings on the setting reaction and immobilizes the resin, but the essence of successful bonding depends upon critical timing of these actions so that only the proper amount of flow takes place before the reaction sets in.

Table 1 records the results obtained with open assembly times of 10 minutes and 20 minutes, preheat temperature 350° F. for 2½, 5, and 7½ minutes, and with pressure of 150 psi for 60 seconds. These results, although quite unsatisfactory, were nonetheless valuable because they revealed the nature of the difficulty and pointed to a possible solution. Apparently, with only 10 minutes of open assembly time the adhesive was too mobile and overpenetrated the wood to give a starved joint which delaminated immediately. An interesting observation was the fact that in all cases of starved joints the adhesive had transferred to the hot surface and overpenetrated that member. With 20 minutes of open assembly time, the 2½ minutes preheating produced starved joints while the 5 and 7½ minutes preheating started to develop some bonding action. This bonding action, however, was very weak since the wood failures were low and were registered only in weak springwood zones.

Table 1.—PRELIMINARY EXPERIMENTS WITH SINGLE PREHEAT LAMINATING. EFFECT OF PREHEAT TIME AND OPEN ASSEMBLY TIME

Preheat Time (min.)	Specimen No.	PSI	WF%	Remarks
10 Minutes Open Assembly Time				
2½	1	Delaminated	--	Appeared Starved*
	2	Delaminated	--	Appeared Starved
5	1	Delaminated	--	Appeared Starved
	2	Delaminated	--	Appeared Starved
7½	1	Delaminated	--	Appeared Starved
	2	Delaminated	--	Appeared Starved
20 Minutes Open Assembly Time				
2½	1	Delaminated	--	Appeared Starved
	2	Delaminated	--	Appeared Starved
5	1	625	10	Springwood Failure
	2	1082	50	Springwood Failure
7½	1	1030	20	Springwood Failure
		490	5	Springwood Failure

Adhesive: resorcinol-phenol A; preheat temp.: 350° F.; pressure: 150 psi; pressure time: 60 sec.; wood: selected, high-density, vertical-grain Douglas-fir.

*Over-penetration.

It seemed obvious from these results that the heat stored in the hot member had both a beneficial and a negative effect. Apparently, the adhesive must at once be sufficiently mobile to flow on the cold surface and, at the same time, be able to resist overpenetration on the hot surface. Since the negative effect was in the direction of imparting excessive mobility to the resin, extended open assembly times appeared to be one possibility of counteracting this effect. The reasonable time limit of 20 minutes for this step, however, had already been reached. Therefore, another approach was needed in order to take full advantage of the stored heat in the boards.

This other approach took the form of a resorcinol-phenol adhesive with cure properties which could be modified with an accelerator. The accelerator reduced both the open assembly time and the cure time by one-half. Additional filler was also added to the extent of 5 per cent with the hope of further controlling mobility of the resin. Preheat temperatures were reduced from 350° F. to 300° F. in order to find a compromise in the effect produced by the heat. The next series of experiments were conducted with open assembly time held constant at 10 minutes while the pressure time was allowed to vary at three levels: 30, 60, and 90 seconds. The 30-second interval was intended to show whether advantage could be taken of the effect of the accelerator added to the adhesive; the 90-second pressure interval was intended to show whether the lower temperature level combined with a longer time under pressure would compromise the negative effect of heat. The results are given in Table 2.

Table 2.—PRELIMINARY EXPERIMENTS WITH SINGLE PREHEAT LAMINATING. EFFECT OF PREHEAT TIME AND PRESSURE TIME

Preheat Time (Min.)	Pressure Time (Sec.)	Average Dry Shear Strengths PSI	WF%	Remarks
2½	30	770	18	Springwood failure
	60	833	15	Shiny areas on glue
	90	749	5	Shiny areas on glue
5	30	290	0	Shiny areas on glue
	60	775	15	Shiny areas on glue
	90	1030	90	
7½	30	647	12	Shiny areas on glue
	60	726	20	Shiny areas on glue
	90	1290	65	

Adhesive: resorcinol-phenol B, with accelerator and additional filler; preheat temp.: 300° F.; pressure: 150 psi; open assembly time: 10 min.; wood: selected, high-density, vertical grain Douglas-fir.

Shear strengths, on the whole, were much improved over those recorded in Table 1, but were still far below the shear strength of the wood as evidenced by the low wood failure readings. The 90-second pressure time seemed to produce the best results, particularly with the 5-minute and 7½-minute preheat time. Since the 30-second pressure time produced inferior joints, it was assumed that the full effect of the accelerator in the adhesive was not being realized.

Careful study of the glue failures on these specimens revealed the presence

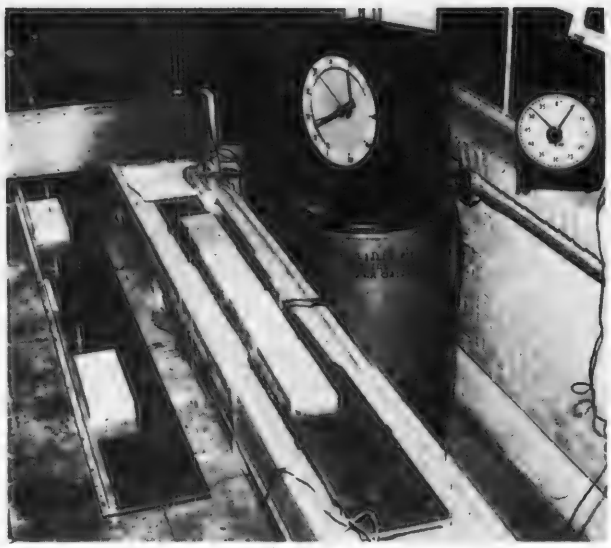


Fig. 4.—Elongated plate heater and press charger for single preheat laminating of 2 x 4's up to five feet long.

of shiny areas in contrast to the uniformly dull appearance of the glue failures associated with overpenetration. These shiny areas were considered to have been caused by lack of contact with the opposite surface. Apparently the 10-minute open assembly time with the accelerated and filled adhesive mixture resulted in a film viscosity which was too high, and neither the heat nor the pressure was sufficient to induce flow. It was concluded, therefore, that both the preheat temperature and the pressing pressure should be increased.

Table 3 gives the average shear values obtained for several combinations of conditions when the pressure was increased from 150 to 200 psi and the preheat temperature increased from 300° F. to 350° F. Other conditions were the same as the previous experiments. In this series of experiments, it was noted that preheating for 5 minutes at 350° F., followed by pressing for 30 seconds, still gave inferior results. Increasing the preheat time to 7½ minutes brought about a 50 per cent increase in shear strength and an 80 per cent increase in wood failure. Alternatively, increasing the press time from 30 to 60 seconds (instead of increasing the preheat time) produced exactly the same percentage improvement in shear strength. Surprisingly, a reduction in preheat temperature from 350° F. to 300° F. produced somewhat better results than a corresponding set of conditions at the higher temperature. These results indicated that a workable compromise of the flow and cure properties of the adhesive had been achieved, but that a higher-than-normal pressure was required.

Table 3.—PRELIMINARY EXPERIMENTS WITH SINGLE PREHEAT LAMINATING. COMPARISON OF CONDITIONS FOR SUCCESSFUL BONDING

Conditions	Average Dry Shear Strengths PSI	WF%
1. Preheat Temp. 350° F. Preheat Time 5 min. Pressure Time 30 sec.	812	48
2. Preheat Temp. 350° F. Preheat Time 7½ min. Pressure Time 30 sec.	1248	83
3. Preheat Temp. 350° F. Preheat Time 5 min. Pressure Time 60 sec.	1288	86
4. Preheat Temp. 300° F. Preheat Time 5 min. Pressure Time 60 sec.	1405	74

Adhesive: resorcinol-phenol with accelerator and additional filler; open assembly time: 10 min.; pressure: 200 psi; wood: selected, high density, vertical grain Douglas-fir.

The results presented in Table 3, with shear strengths of 1200 to 1400 psi and wood failures of more than 70 per cent, were more in keeping with what was expected from the selected Douglas-fir stock. In addition, the conditions were all within the stipulated ranges which were desired for a production operation. Further encouragement was gained from the fact that a predictable reciprocity law seemed to be governing the factors involved in the bonding action under these conditions, a fact which would lend a degree of latitude much desired in the ultimate design of production equipment.

The next series of experiments involved an attempt to incorporate the above results into a laboratory procedure for producing laminated 2 x 4's from typical No. 4 common, 1 x 4 stock. The equipment, shown in Fig. 4, consisted of an elongated plate-type heater capable of preheating boards up to five feet long, a charging plate for rapid loading into the press, a hydraulic press, and a glue spreader. A fast-acting recording potentiometer was used to measure glue line temperatures. A three-man team was used to operate this set-up in order to obtain the necessary speed in handling the members.

A number of runs were made with this equipment in an attempt to produce consistently acceptable 2 x 4's with an accelerated resorcinol-phenol adhesive. Preheat temperatures were 350° F.; preheat time, 5 minutes; pressure, 200 psi; pressure time, 60 seconds; and open assembly time, 10 minutes. Both white fir and red fir were included in these experiments. Typical results are given in Table 4. These data were not corrected for low-strength wood as normally required in appraising the quality of a gluing operation,[2] because they were intended only to indicate the possibilities of the process. Actually, the data would be considered as quite encouraging; although the strengths are somewhat below the average requirements for the species,[3] the wood failures are at a satisfactory level for both the dry and the boil test. There was some indication that the center of the 2 x 4's was better bonded than the edges. This was believed to be a temperature effect which probably could be eliminated in a continuous production set-up.

Two circumstances occurred at this point which caused abandonment of the technique of heating one member

Table 4.—AVERAGE SHEAR STRENGTH OF LABORATORY 2 x 4'S LAMINATED FROM NO. 4 COMMON KILN DRIED 1 x 4'S BY THE SINGLE PREHEAT METHOD

Piece No.	Dry PSI	Dry WF%	12-Hr. Boil PSI	12-Hr. Boil WF%
White Fir				
1 Center	732	95	588	87
Edge	602	68	282	75
2 Center	910	63	395	80
Edge	712	85	431	92
3 Center	1130	100	595	93
Edge	697	93	580	100
4 Center	933	93	597	100
Edge	930	80	583	95
Red Fir				
1 Center	568	60	660	100
Edge	1091	93	868	95
2 Center	846	93	702	75
Edge	756	97	691	85
3 Center	800	53	437	55
Edge	381	15	281	3
4 Center	1308	50	831	85
Edge	901	95	760	80

Adhesive: resorcinol-phenol B with accelerator and filler; preheat temp.: 350° F.; preheat time: 5 min.; pressure: 200 psi; pressure time: 60 sec.; open assembly time: 10 min.

[2] Correction involves elimination from the average of any specimen whose recorded strength is below a certain value and whose wood failure reading is above 75%. Application of this correction tends to increase the average strength and decrease the average wood failure in a set of data.

[3] Fabrication and Design of Glued Laminated Wood Structural Members, USDA, Technical Bulletin No. 1069, February, 1954. This bulletin gives 1100 psi and 50% wood failure for Douglas-fir dry and 756 psi and 75% for the boil test. Corresponding values for white fir calculated on the basis of density are 910 psi dry and 648 psi boiled.

and applying adhesive to the other. One was an observation that a number of assemblies delaminated at the ends, probably because of poor temperature control on the hot plate, and these always displayed considerable bowing in one member. This was believed to be either a moisture effect or a thermal effect, both of which were related to the preheating step, and since only one member was heated, the two-piece assembly had to be unbalanced with respect to both these effects. Because this effect had become evident on 2 x 4's only five feet long, it was obvious that internal stresses from these sources would be worse on longer members. It was conceivable that 16-foot 2 x 4's would be excessively warped even though they might not actually delaminate.

The second circumstance was the realization that the glue costs for the resorcinol-phenol adhesive required in this method would be about $12.50 per 1000 bd. ft. of 2 x 4's. This did not leave an adequate margin for a reasonable gamble on the probable cost of the balance of the gluing operation. If the project were to be successful, therefore, a reduction in glue costs had to be achieved. The only hope was to find a way to make use of the lower cost straight phenols.

Double Preheat

A seemingly fantastic suggestion by Potlatch personnel finally proved to be the turning point in this dilemma and eventually led to the present successful pilot plant operation. Why not preheat both surfaces? The additional heat needed to cure the phenolic adhesives might then be available at the bonding surfaces. On the face of it, this suggestion appeared to have no merit because it ran counter to accepted theories of adhesive action. How, for example,

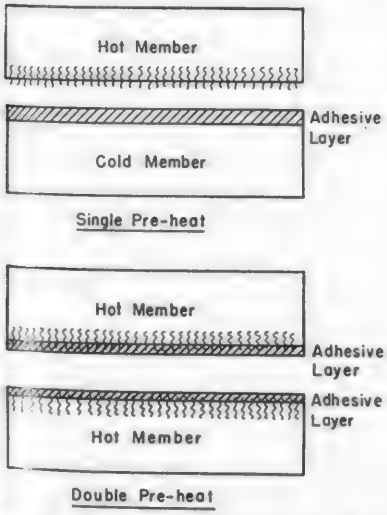


Fig. 5.—Relationship of component parts in laminating 2 x 4's by the preheat method.

Fig. 7.—Equipment and crew for double preheat laminating of short billets of 1 x 4 stock.

could one expect to prevent damaging precure from taking place before pressure could be applied? Precure is known to be a common cause of plywood delamination, and it usually occurs in hot presses while the press is being closed on the plywood lay-ups. Therefore, if adhesive is spread on a wood surface heated to about the same temperature as the hot platens of a plywood press, it would appear to be an open invitation to precure. Nevertheless, the idea persisted because of the great reduction in adhesive costs, from $12.50 to $2.50 per 1000 bd. ft. of 2 x 4's, and because of certain other possible simplifications in the production line.

Eventually, experimentation was begun, and it was found that the heat stored when both surfaces are preheated is considerably greater than when only one surface is preheated. (For convenience, these two methods will be referred to as "double preheat" and "single preheat," see Fig. 5.) Fig. 6 gives the glue line temperatures recorded for both double and single preheating on a hot plate at 350° F. for five minutes. In both cases the temperature record was delayed for several seconds while the thermocouple was being placed and the assembly brought under pressure.

In double preheating, the glue line temperature dropped from the plate temperature to about 240° F. at the end of 60 seconds, while with single preheat the glue line temperature dropped to about 170° F. in the same interval. As far as heat storage is concerned, it appeared reasonable to assume that a high percentage of the total cure of a phenolic resin could be achieved in 60 seconds under pressure by the double preheat method. Successful gluing, however, would still be dependent upon speed of handling from resin application to pressure application.

The curves of Fig. 6 represent a composite of both white fir and red fir. In actual practice it was found by Potlatch research personnel that the denser red fir was able to store more heat than the white fir. One practical advantage of this fact was the possibility that it would be an automatic self-compensating device which would insure that the denser pieces attained a higher degree of resin cure before release of pressure.

The laboratory procedure for double preheat experiments was somewhat the same as had been used for single preheating, except that both members were spread with adhesive and an additional step was added to the high-speed handling sequence. Only short billets of wood were used because of the limitations of speed in handling. Actual timing indicated that at maximum speed, 3 seconds were required to remove blocks in pairs from the preheater and pass through the spreader, 2½ seconds to mate the glue-spread surfaces and charge into the press, and 2½ seconds to close the press and bring it to full pressure. Three men were involved in this sequence of operations, as shown in Fig. 7.

After some practice in rapid handling of hot blocks, it was found that neither precure nor overpenetration were in evidence on the sheared joint

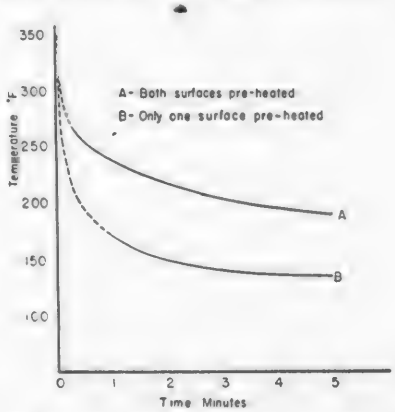


Fig. 6.—Glue line temperature curve following preheating at 350° F. for 5 minutes.

Table 5.—SHEAR STRENGTH OF LABORATORY 2 x 4'S LAMINATED FROM NO. 4 COMMON KILN-DRIED RED FIR 1 x 4'S BY THE DOUBLE PREHEAT METHOD

Piece No.	Specimen No.	Dry Shear Strengths (PSI) 30 Sec. Pressure Time 8 Sec.* CAT	12 Sec. CAT	16 Sec. CAT	60 Sec. Pressure Time 8 Sec. CAT	12 Sec. CAT	16 Sec. CAT
1	1	700	1295	1130	1620	1615	890
	2	1670	1075	950	1555	1305	1050
	3	1030	1125	865	1570	1595	1000
	4	1345	1210	890	1705	1575	990
2	1	1495	995	1230	1330	1400	1215
	2	1390	1125	1175	1110	1355	1255
	3	1185	1055	920	1485	1395	1275
	4	995	1020	1260	1215	1545	1700
3	1	1195	606	815	1160	1105	765
	2	1465	1090	845	1325	1085	560
	3	----	1220	860	1285	1145	215
	4	----	785	1060	1150	1105	935
4	1	1285	1305	1050	1120	925	920
	2	1000	1320	280	1005	1045	225
	3	1155	1135	595	855	985	535
	4	1035	1100	1330	1170	1285	965
5	1	1420	1500	375	1395	1185	1105
	2	1450	1030	127	1680	900	930
	3	1530	1465	117	1615	1065	660
	4	1410	1150	295	1195	1220	1330
Closed Assembly Time Ave.		1271	1131	814	1327	1241	926
Pressure Time Ave.			1072			1165	

Preheat temperature: 350° F.; preheat time: 5 min.; open assembly time: 0; pressure: 200 psi; phenolic adhesive with extender.

*Closed Assembly Time.

surfaces. In these experiments, a total of 8 seconds elapsed from the time the wood left the preheater until it was under pressure. The hot, glue-spread surfaces were in contact for about 4 or 5 seconds before full pressure was applied. These preliminary findings were highly encouraging.

One more item of information was now needed before consideration could be given to a means of converting the laboratory procedure into a production process. This item concerned the allowable tolerance on closed assembly time. Design engineers needed to know the limit on closed assembly time before adverse results could be expected. Table 5 gives the results of extending the closed assembly time from 8 seconds, to 12 seconds, and finally to 16 seconds. These three intervals included the total time from the preheater to application of full pressure since this time was all related to the temperature effect. Actual contact time before pressure application was about 4, 8, and 12 seconds, respectively. Two pressing intervals were included, 30 and 60 seconds, in order to determine how much latitude existed in the pressure interval.

These experiments were designed on a matched block basis so that each piece of 1 x 4 material provided billets for each of the pairs of variables involved. This type of experimental design eliminated the need for wood-failure readings as an adjunct to the strength readings because the factors most responsible for wood-failure variation were shared alike by the variables under investigation.

The results, Table 5, showed that 8- and 12-second assembly times yielded acceptable joints for both the 30- and 60-second pressure period. However, there was a definite decrease in strength as the assembly time was increased from 8 to 16 seconds. The decrease in strength for 12 seconds was about 10 per cent for both the 30-second and 60-second pressure interval. Doubling the pressure interval from 30 to 60 seconds yielded about 10 per cent greater strength for all corresponding assembly time intervals. The 16-second assembly time interval resulted in a marked loss of strength, in the order of 30 per cent lower than the 8-second interval.

Technical difficulties prevented experimentation on five-foot 2 x 4's by the double preheat method in the laboratory. Conclusions in regard to performance specification for the equipment, therefore, had to be drawn from the results given in Table 5. The principal requirements set forth on the basis of these data were the following: preheating, 350° F. for 5 minutes; assembly time total not more than 12 seconds, preferably 8; pressure, 200 psi; and pressure interval, 60 seconds.

Strength of Heated Wood

One of the features of some concern in this program was the possible reduction of strength at the heated surface due to the relatively high temperatures. To evaluate possible effects, end matched samples were prepared for block shear glue tests. Test pieces were first exposed to high temperatures similar to the double preheat technique, then allowed to cool. To permit curing at room temperatures, phenol-resorcinol glue was used for both test and control specimens. These pieces and unheated control pieces were then pressed in clamps at room temperature overnight and allowed to condition an additional 8 days before testing.

No significant difference was found between the strengths of the blocks prepared in the two different procedures.

About the same time this work was underway, a paper by J. D. MacLean of the U. S. Forest Products Laboratory,[4] disclosed that heating up to 2 hours at the temperature suitable for the double preheat technique would cause no loss in modulus of rupture and no loss in work to maximum load for Douglas-fir.

These results led to the conclusion that there are no detrimental effects from the preheating step.

Theory of Double Preheat Laminating

As can be seen from the sketches in Fig. 5, the double preheat method results in a balance of the thermal effects about the midpoint of the completed assembly. This balance is highly important in two-member assemblies of substantial length because it eliminates the tendency to bow. The double preheat method also has the further advantage of producing an identical condition at both interfaces for the bonding action of the adhesive thereby simplifying the requirements for the adhesive. In the single preheat method, by contrast, the adhesive is subjected to conflicting circumstances at the two interfaces and optimum conditions for the two actions are more difficult to maintain.

Some further explanation seems warranted as to why the double preheat method works at all in view of the fact that it appears to violate previously accepted principles of adhesive action. It is possible that a certain amount of precure does take place during the short interval of time when the adhesive is in contact with the hot surfaces without pressure. The absence of pressure at this point, however, may be more beneficial than detrimental because it delays one of the forces which tends to cause overpentration. Some precure, therefore, may be operating to prevent overpentration. Precure may take place predominately below the surface of the wood, and the reaction probably proceeds progressively toward the exposed surface of the adhesive film. When a surface in this condition is brought into contact

[4] MacLean, J. D. 1955. Effect of oven heating and hot pressing on strength properties of wood. Proceedings, American Wood-Preservers' Association, pp. 227–249.

with a similar surface, the most unreacted parts of the film meet to form the final cohesive bond. It seems possible, therefore, that under this sequence of actions the adhesive link between resin molecules and the wood structure is formed largely without pressure.

The principal points of contrast in the single preheat method are: first, that the sequence of adhesive actions are entirely different on the two surfaces, one hot and one cold, and second, that both pressure and heat are applied instantaneously to the adhesive film. As pointed out above, this simultaneous and instantaneous application of heat and pressure encourages overpenetration into the hot surface. Steps in resin formulation which may be taken to counteract this overpenetration are likely to detract from its bonding potentialities with the cold surface.

Pilot Plant Manufacture of Laminated 2 x 4's

While the investigations of heating, assembly times, and pressing were nearing completion in the Division laboratory, the Research Department at Potlatch Forests began exploring methods of heating long pieces. It was evident at the outset that platen heating would be unsatisfactory for normal lumber because even slight deviations in the lumber from a true plane would seriously reduce the efficiency of the heating element. There was also the problem of pitch exuding from the hot boards onto the platen. Radiant heating offered the best possibility.

Studies were therefore undertaken at Potlatch to convert from platen to radiant heating Division research had established not only proper heating periods on hot plates but also glue line temperatures developed. To measure the effect of hot plate heating, specimens of Douglas-fir and white fir were prepared with thermocouples located 0.023 inches below the surface of the wood. With these test pieces, temperatures at that point were determined with the piece on a hot plate. Temperature at the thermocouple reached 305° F. when placed on a hot plate at 350° F. for 5 minutes.

Having established the effect of the hot plate by such a temperature measurement it was a simple matter thereafter to determine how long an interval was required for other types of heat to provide the same temperature. It was finally disclosed that heating under a calrod unit for 60 to 120 seconds provided the necessary stored heat in the surface of the wood.

After the pilot plant was constructed, heating intervals were again thoroughly evaluated on the machine by Potlatch research personnel to arrive at the heating schedules now being used. In general, these schedules fell within the 60- to 120-second range established through the use of thermocouples in small test specimens.

With the information supplied by the research laboratories, engineers at Potlatch designed the equipment shown in Figs. 8a and 8b. This pilot plant was set up to manufacture 2 x 4's eight feet long, a length which would provide a salable product as well as test the soundness of the process. The process is continuous and fully automatic, requiring only two men to operate.

Kiln-dried 1 x 4 stock of approximately 8 per cent moisture and dressed slightly oversize is fed by hand to the in-take chain. Excessively warped pieces are sorted out and run separately as a group. Occasionally, these warped boards fail to stay in line and cause difficulty at some point in the process. The in-take chain feeds directly below radiant heaters at a rate corresponding to the amount of stored heat desired.

From the preheater, the boards are conveyed rapidly end-wise, two at a

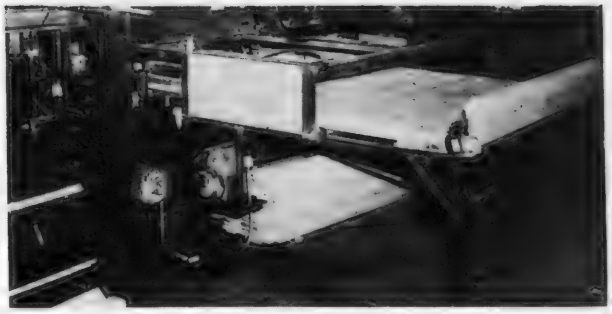


Fig. 8a.—Intake end of pilot plant machine for laminating eight-foot 2 x 4's by the double preheat method.

Fig. 8b.—Rotary press and discharge end of laminating machine.

Fig. 9.—Load of laminated 2 x 4's ready for shipment.

Table 6.—SHEAR STRENGTHS OF PILOT PLANT 2 x 4'S LAMINATED FROM NO. 4 COMMON KILN DRIED WHITE FIR 1 x 4'S BY THE DOUBLE PRE-HEAT METHOD

Piece No.	Specimen No.	Strength Dry		Strength After 12-Hr. Boil	
		PSI	WF%	PSI	WF%
1	1	595	45	700	40
	2	665	25	670	60
2	1	1045	90	715	85
	2	755	70	685	90
3	1	545	80	595	75
	2	915	100	580	80
4	1	1190	75	725	60
	2	1250	95	735	85
5	1	830	15	540	90
	2	995	80	615	90
6	1	835	100	805	100
	2	1305	95	605	90
7	1	580	90	635	90
	2	570	80	615	100
8	1	960	95	605	100
	2	1040	95	525	95
9	1	835	100	685	90
	2	700	85	645	100
10	1	1000	95	665	90
	2	1070	60	715	95
Ave.		889	79%	653	85%
Corrected Ave.		980	75%	690	79%

time, beneath an ingenious nozzle-type glue spreader. After spreading, the two boards again traverse side-wise, glue-spread face up, to an elongated trap door through which they fall face-to-face into the pocket of a rotary press. Pressure is now quickly applied as the press indexes to the next pocket and another pair of 1 x 4's starts out from the preheater. Meantime, one of the six pockets on the press has discharged a completed 2 x 4.

The End Product

This unit has a capacity of about 6000–8000 bd. ft. of laminated 2 x 4's per day. These 2 x 4's are dressed with corners relieved, then trimmed, after which they are end-treated and attractively end-marked. The result is a product with considerable customer appeal (Fig. 9).

Considering the type of the stock being glued, the quality of the glue joints are surprisingly good. Table 6 gives the shear results of 10 white fir 2 x 4's picked from a day's production. The corrected average of 980 psi and 75 per cent wood failure for the dry test, and 690 psi and 79 per cent wood failure for the boil test are above the minimum requirements. These results indicate a satisfactory level of bonding efficiency.

Table 7 gives the results of cycle delamination tests obtained on the same sample of 2 x 4's reported in Table 6. These tests were conducted by the Timber Engineering Company, Washington, D. C., using the 12-day pressure-vacuum cyclic delamination test, a procedure which involves alternate wetting and drying of the specimens. The highest average delamination recorded for any sample was 2.4 per cent. Compared with a permissible delamination of 10 per cent, these joints would be considered excellent.

From the limited sales experience so far accumulated with this product, it is evident that the advantages offered are appreciated by the consumers. One contractor has voluntarily stated that because of the straightness of pieces in a shipment of laminated 2 x 4's, he could afford to pay up to $8.00 per 1000 bd. ft. more for the laminated product than for a comparable grade of solid 2 x 4's.

Another distinct advantage is the assurance of truly dry material rather than material in various unknown stages of "dryness." The drying of one-inch stock is more rapid and produces more uniform drying in commercial operation than is possible with dimension stock.

Salesmen also report that many people now readily accept the fact that the glue joint is stronger than the wood, others require some convincing. For the latter, test data are less convincing than a demonstration such as pictured in Fig. 10 in which spikes are driven into the joint in close proximity. Sixteen- and twenty-penny spikes driven all the way through the 2 x 4 caused no separation of the laminations.

Patents

Patent application has been made on the fundamental principles of the new method of hot gluing which involves preheating both surfaces of the members to be glued. A previous patent,[5] now expired, has been found which covered the method of gluing in which only one member was heated while a thermosetting glue was spread on the other surface. This patent, however, seems to have found no commercial application. The discovery that successful gluing could be accomplished with both surfaces preheated is sufficiently unique to warrant expectations of a patent being granted on this application. Patent applications are also being prepared on the apparatus developed for use in this process.

Fig. 10.—Visual demonstration of the integrity of the glue joint in laminated 2 x 4's.

Table 7.—RESULTS OF CYCLIC DELAMINATION TESTS ON LAMINATED 2 x 4'S*

Sample Number	Glue Line	Length	Delamination Length	Delamination
				Per cent
1	1	7.4	0.00	0.0
	2	7.3	0.44	6.0
	3	7.3	0.00	0.0
	4	7.2	0.00	0.0
			Average	1.5
2	1	7.2	0.00	0.0
	2	7.3	0.56	7.8
	3	7.2	0.00	0.0
	4	7.3	0.13	1.7
			Average	2.4
3	1	7.2	0.00	0
	2	7.3	0.38	5.2
	3	7.2	0.00	0.0
	4	7.3	0.06	0.9
			Average	1
4	1	7.4	0.00	0
	2	7.4	0.13	1.8
	3	7.2	0.00	0
	4	7.3	0.16	0.0
			Average	0

*From a report by Timber Engineering Co., Washington, D. C.

Conclusion

Pressure periods of a duration reported in this research have heretofore been approached in lumber products only with the use of high-frequency heating. With this preheating method, it is now possible to achieve economies not only in the equipment, but also in glue costs with no sacrifice of bond quality. The practical effect of these economies will be to expand the application of gluing to the many new problems of the lumber industry, particularly to the problem of low-grade lumber. Laminated beams for today's modern homes at a cost within reach of the average home builder is an imminent possibility of the preheat laminating method.

[5] U. S. Patent No. 1, 851, 709. March 29, 1932. I. F. Laucks Co.

Handbook for Small Sawmill Operators

How to Attain and Maintain Accuracy of Cutting

Prepared by

LOGGING AND MILLING COMMITTEE, FOREST PRODUCTS RESEARCH SOCIETY

Preface

The *Handbook For Small Sawmill Operators* was prepared by the Logging and Milling Committee of Forest Products Research Society at the request of Sectional Committee B-66 of the American Society of Mechanical Engineers. This latter committee was organized at the request of the Office of Defense Mobilization of the U. S. Government to consider "establishment of performance standards for equipment at small sawmills with a view to securing increased precision of sawing and minimum waste of material."

The material in this Handbook has been divided into six parts, which will be published serially in the FOREST PRODUCTS JOURNAL and later as a separate bulletin which will be available from the Standards Department of ASME, 29 West 39th Street, New York 18, N. Y.

Publication of this Handbook by FPRS and ASME is not to be construed as establishing any new dimensional standards for lumber. Such standards are promulgated by the American Lumber Standards Committee for softwoods and by the National Hardwood Lumber Association for hardwoods. It is designed specifically to show the small sawmill operator how he can produce lumber to those standards more economically and most efficiently.

Acknowledgment is due many people, representing the several groups interested in the small sawmill business in various ways, for the constructive help and advice given in this handbook compilation job. Such help has been received from so many people and firms that it would be impossible to mention them all individually. The source of many of the photographic illustrations used is indicated in the text. Many of the pen and ink sketches were made by T. D. Perry, Chairman of Sectional Committee B-66. Agricultural Handbook No. 27, Small Sawmill Operators Manual, U. S. Department of Agriculture, Washington, D. C., and Sawmilling Practices that Pay, by R. R. Cahal, Southern Pine Inspection Bureau, New Orleans, La., were drawn upon freely.

The Committee is very grateful to all those who helped so generously.

FRED C. SIMMONS,
Chairman
FPRS Logging and
Milling Committee

Introduction

FRED C. SIMMONS

Specialist in Logging and Primary Processing, Northeastern Forest Experiment Station, Forest Service, U. S. Department of Agriculture, Upper Darby, Pa.

and

JAMES S. BETHEL

Director, Wood Products Laboratory, North Carolina State College, Raleigh, N. C.

Small sawmills can produce accurately sized lumber if they are well constructed, properly maintained, and correctly operated. This Handbook summarizes the causes of miscut lumber in small mills and indicates the action that the sawmill operator can take to eliminate these causes.

Purpose of Handbook

A VERY SUBSTANTIAL PROPORTION of the lumber produced by the American lumber industry is manufactured on small sawmills. Lumber that is poorly manufactured from the standpoint of uniformity of dimension may be the cause of complaint by the lumber buyer, and is costly to the manufacturer because of excessive waste. This problem has been the subject of much research and there is ample evidence to show that small sawmills can produce accurately sized lumber. If the small mills are well constructed, properly maintained, and correctly operated, they will produce lumber that is satisfactory for every type of use. The purpose of this Handbook is to summarize the causes of miscut lumber in small mills, and to indicate the action that the small sawmill operator can take to eliminate these causes when they appear in his operation.

Definition of Small Sawmill

The term "small sawmill" has never been exactly defined. It has a different meaning for people from different parts of the country. Sawmills may be classified as small or large on the basis

The Authors: Fred C. Simmons received B.S. from Cornell U. and M.F. from Yale School of Forestry. He is author of U. S. D. A. Northeastern Loggers Handbook, Bulletin on Sawmill Techniques, and numerous papers on logging and milling. Simmons is Chairman of the FPRS Logging and Milling Committee.

James S. Bethel holds B.S. from U. of Washington, M.F. and D.F. degrees from Duke U. He was associated with U. S. Forest Service, Penn State College, Virginia Polytechnic Institute, and Tidewater Plywood Co. before joining N. C. State faculty as Professor of Wood Technology in 1949. Bethel is Secretary-Treasurer of Carolinas-Chesapeake Section, FPRS, and a member of the Society's Publications, Industry-Education, and Quality Control Committees.

of cost, production rate, size of saw, or size of power unit. None of these bases for classification is completely satisfactory. Productive capacity per day is most often used. In the Pacific Northwest, a sawmill cutting 20,000 board feet a day would be considered a "small sawmill". In southern New England a mill cutting at this rate would be considered a large sawmill.

Moreover, mills with essentially the same equipment and the same amount of manpower cut at widely different rates, depending on the thicknesses produced, the size of the logs handled, whether they are cutting hardwoods or softwoods, and how much attention is paid to grade or quality of product.

For the purpose of this Handbook a "small sawmill" will be considered to be one that is cutting less than 20,000 board feet per day of boards, dimension, or timbers, for the commercial lumber market. No effort will be made to consider the special problems of the very small mill cutting material for home use, or the local custom market.

Need for Dimensional Control

The average diameter of logs delivered to sawmills in most regions, throughout the country, is smaller than it was in former years. In some areas where new forest growth has balanced drain, this trend has recently been reversed, but small log sizes will continue to plague the industry for many years to come. The percentage of the total cubic volume of these smaller logs that can be manufactured into lumber of standard sizes, even by the best methods, is bound to be less than that obtainable from larger logs. Costs per thousand board feet consequently are higher. As the percentage of higher grades is generally also greater in large diameter logs than in smaller logs, sawmill operators are faced with the problem of producing a maximum of merchantable product at a minimum cost from the logs available to them. To do this requires careful methods of sawing designed to extract maximum yield, especially of the higher grades. Much can be done to improve yield and product salability through more accurate sawing.

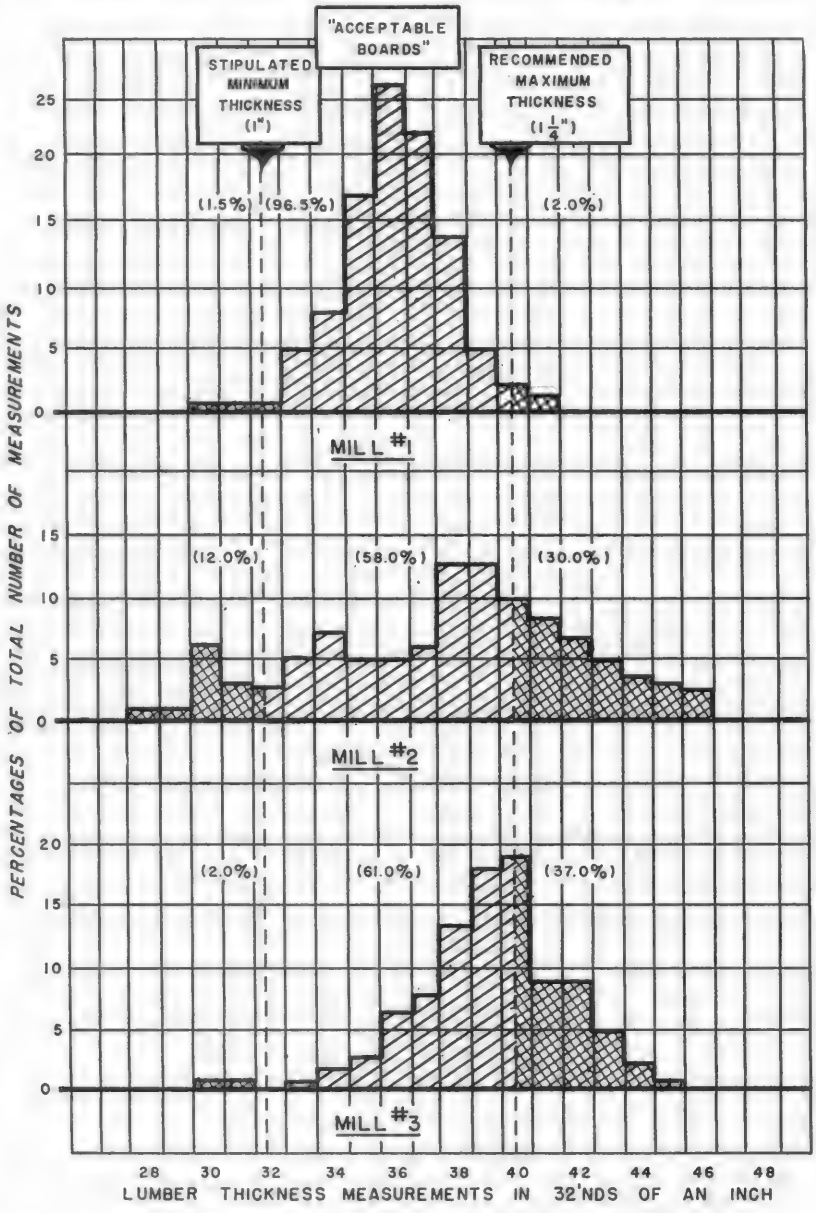


Fig. 1.—Results of lumber thickness measurements in three mills.

Lumber which is too thin has limited usefulness. If it is delivered to the customer, it is likely to be unsuitable for the purpose intended. This, of course, creates customer ill-will, makes repeat sales more difficult, and creates an atmosphere in which the sales of lumber substitutes are likely to flourish. If the thin lumber is not delivered to a customer, it must be remanufactured to a smaller standard dimension, sold as cull, or carried out with the slabs and edgings. None of these courses represents good business practice.

Many lumber manufacturers, recognizing the desirability of eliminating thins, go to the other extreme and set for such a heavy over-thickness that even the thinnest boards meet the minimum size specifications. This constitutes a poor solution to the problem of miscutting. The millman does not get the footage that the logs he saws are capable of producing. The customer, if he is going to surface the lumber, dislikes excessively thick boards because they overload his planing equipment and increase his waste handling and disposal problems. Producing overthick stock also means that someone is going to spend time and money handling wood from the stump to the customer for which he is not going to be paid. Drying excessively thick stock, particularly in a kiln, is also unnecessarily expensive.

It has been found that many small sawmills put from 10 to 20 per cent more volume into their product than is needed. This means higher costs, lower profits, higher prices, and a poor market position with respect to competitive materials.

The answer to the sawmill operator's problem is to do an accurate sizing job. It is recognized, of course, that it is impossible to produce all lumber of the same nominal thickness to precisely the same thickness rough green, and fresh from the saw. Sawmills, like all other pieces of manufacturing equipment, yield products which vary in size. Successive 4/4 boards from even the best sawmill will vary in thickness from board to board. This is to be expected and accepted. It is just as true, however, that the boards need not vary

over a wide range in thickness. The variation can be controlled within reasonable limits if the sawmill is operated correctly.

Controlling Lumber Thickness

The best way to determine whether or not a small sawmill is doing an acceptable job of lumber sizing is to measure the thickness of a representative sample of the material it is producing. A small caliper, graduated in thirty-seconds of an inch, is a useful tool for doing this.

In Fig. 1, the results of about 600 measurements of this type from each of three mills, selected to represent various typical conditions, are summarized graphically. The product of these three mills was measured as part of a study of about 150 mills throughout the country conducted by a subcommittee of which the authors of this Section were members, with the cooperation of the U. S. Forest Service, and a number of state research institutions and schools of forestry. The detailed results of this study will be reported in other publications.

The chart for Mill #1 illustrates the grouping of measurements to be expected when a sawmill is being properly operated and is in good condition mechanically. It is evident that the pattern of lumber thicknesses produced varies on either side of the average board thickness in a symmetrical pattern. This pattern is called a "normal distribution". When lumber thicknesses fit this pattern the sawmill operator can set the mill, as the operator of this mill has done, to cut the smallest possible average board thickness, and remain assured that he will produce a minimum of boards that are too thin. When the pattern of lumber thicknesses fits the normal distribution curve, the milling operation is said to be "in control".

When a sawmill is poorly constructed, incorrectly maintained, or carelessly operated, the pattern of lumber thicknesses will not fit the normal distribution and, in fact, the pattern is not predictable. This is illustrated in Fig. 1 by the graph made from the measurements taken at Mill #2. Thicknesses vary excessively at such a mill, and since there is no pattern to their distribution, the sawmill operator must set for a very heavy average board thickness to assure himself that most of the boards will be above the minimum thickness the purchaser will accept.

Operators of mills that are operating reasonably well "in control" also set for too heavy average thicknesses, as illustrated in the graph of the measurements taken at Mill #3. This mill operator, purposely or accidentally, was cutting his average board nearly 1¼ inch thick, and was producing 37 per cent of his lumber in thicknesses greater than that. If he had set for 1⅛ inch thickness, as the operator of Mill #1 had, 6½ per cent of his lumber would have been less than an inch in thickness, but he would have been obtaining approximately 10 per cent more acceptable board footage out of the logs cut. Tightening up the control limits for this mill, by methods explained in subsequent sections of this Handbook, would undoubtedly reduce the percentage of thins experienced with this closer setting.

From the results of this study, the subcommittee concluded that the average small circular mill properly maintained and properly operated could be expected to produce at least 90 per cent of its boards within plus or minus an eighth of an inch from the average, or within a total thickness range of ¼ inch. These are, consequently, the recommended "control limits" for the production of boards at the average small mill. Some mills are doing, and others can do, much better than this. The minimum thickness for each size cut would, of course, be that mutually agreed upon between the producer and the purchaser of the lumber. This will, in most cases, be based on American Lumber Standards for softwoods, or standards of the National Hardwood Lumber Manufacturers Association for hardwoods.

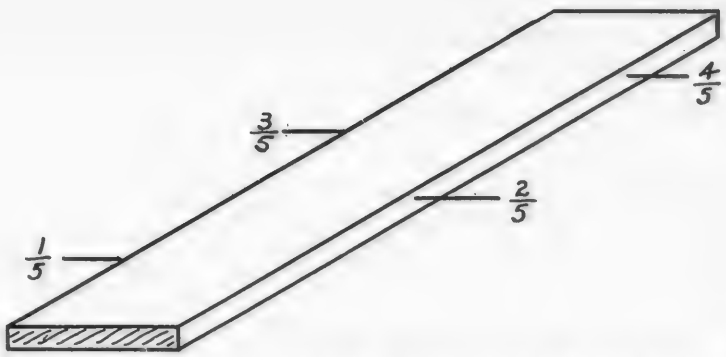


Fig. 2.—Recommended points for checking lumber thickness. On one edge, make measurements at 1/5 and 3/5 piece length, on the other at 2/5 and 4/5 piece length.

For thicker cuttings than boards, it is suggested that these control limits might be increased—to ⅜ inch for material between 2 and 5 inches in thickness, and to ½ inch for timbers (over 5 inches thick). These thicker cuttings are much more apt to come out of the centers of the logs, where any mechanical and operational inaccuracies in the mill tend to accumulate. Generally, also, the purchaser is more willing to accept greater variations in thickness in this heavier material.

It has been found that a convenient and easy way to obtain thickness measurements is to take them at the points on each piece of lumber indicated in Fig. 2. These points give adequate representation to variations that occur in the pieces from end to end and from side to side.

An easy way to apply these recommended control measures at the small mill is by use of a "Go-and-no-go" gage, such as the one illustrated in Fig. 3. This can be made from a piece of strap iron or brass. In this gage, the width of the interior notch is the minimum lumber thickness specified, and the width of the exterior notch is the corresponding maximum thickness decided upon. If a piece of lumber does not fit into the gage at all, it is too thick. If it will go into the inner notch, it is too thin. If it goes into the first notch but will not enter the second notch, it is correct in thickness.

At one mill with which the authors are familiar, when use of these gages was started 30 per cent of the pieces produced were indicated to be outside the control limits. Within a few weeks, however, by application of measures

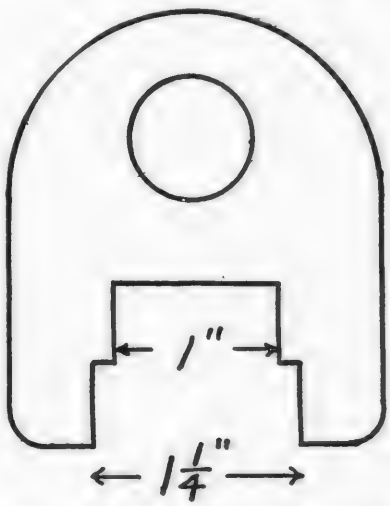


Fig. 3.—Go-and-no-go gage recommended for checking thickness. Easily made from light steel or brass, this gage is for nominal 4/4-inch lumber, with agreed minimum thickness set at 1 inch even.

such as those recommended in subsequent sections of this Handbook, the percentage of unacceptable pieces was reduced to 3 per cent.

For those desiring to go into quality control on a more intensive basis, accurate measurements of each piece to the nearest 1/32 of an inch should be obtained at the recommended points. More elaborate and informative methods of analyzing the data obtained have been devised for the small operator who wishes to obtain the maximum dimensional accuracy for his mill. These are described and illustrated in *Quality Control in Lumber Manufacture* by J. S. Bethel, A. C. Barefoot, and D. A. Stecher, in PROCEEDINGS, FOREST PRODUCTS RESEARCH SOCIETY, 1951.

It cannot be over-emphasized that the only way to assure that a sawmill is producing well-manufactured lumber is to maintain constant vigilance over the thickness of the product. Setworks readings often cannot be depended upon as a guide to the thicknesses being produced. This is especially true when the mill gets a little old, and vital parts become worn. The following Sections of this Handbook will indicate some of the most important causes of miscutting, and provide clues to the particular causes that are operating when thickness measurements reveal mismanufacture to be present.

A Short System for Pro-Rating Direct Labor Cost in Furniture Plant Rough Mills[1]

J. W. CREIGHTON

Department of Forest Products, Michigan State University, East Lansing, Mich.; Baker Furniture, Inc., Holland, Mich.[2]

Time studies of furniture plant rough-mill operations are difficult and time-consuming. This paper shows how cost ratios between different lumber grades, and between cutting lengths, may be used to estimate the direct labor cost of processing cuttings of different sizes from different lumber grades.

THE PROCESSING OF HARDWOOD LUMBER in a furniture plant rough mill is a series of single operations. Boards are brought in from the dry kiln; cut to required lengths; planed to make them flat, smooth, and required thickness; joined to make the edges straight; ripped to required width; and perhaps glued together. These processes are so common that they are followed in many home and school shops. They may be done with hand tools or by small machines instead of by the large machines used in the furniture factories, but basically the operations and tool actions are the same.

Efficient planning of a rough-mill operation is difficult in spite of the ease of working and handling wood. This is because no two boards are alike. In any shipment of hardwood lumber, boards are of different widths and lengths. The boards may have many defects, and the nature and location of these defects may be infinitely varied. Almost the only thing that boards in any one grade, species, thickness and surface measure have in common is that they will contain nearly the same percentage of clear wood.

One board may be cut to several widths and lengths. In cutting up the board, the operators of the machines must make decisions as to the best combination of lengths and widths to cut. Operations are further confused by non-productive jobs, such as cutting out defective portions of the boards, turning the boards over to look for defects, and measuring to make sure that pieces are of required size.

The lack of uniformity of hardwood lumber and the resulting variability in rough mill procedures make it difficult to make effective time studies, and to determine costs accurately. For this reason, costs have been assumed to be directly dependent upon the quantity of rough lumber processed, and therefore, inversely proportionate to the yield per cent from the different lumber grades. Creighton[3] has shown that fairly constant relationships exist between direct labor costs to process different grades, but that they are not in inverse proportion to yield per cent.

Time studies for rough-mill operations are difficult and time consuming. The purpose of this paper is to show how cost ratios between different lumber grades, and between cutting lengths, may be used to estimate the direct labor cost of processing cuttings of different sizes from the different lumber grades.

[1] Final in a series of three contributed papers on the relationship between lumber grade and conversion cost in furniture plant rough mills.

[2] Studies were conducted at Baker Furniture, Inc., while the author was on the Michigan State U. faculty.

The Author: J. W Creighton holds Ph.D. in Wood Technology from U. of Michigan. He joined Baker Furniture, Inc. in October 1955, was formerly Associate Professor of Forest Products, Michigan State U., and Vice-President, Bacon Lumber Co., Sunman, Ind.

Development of Direct Labor Grade Cost Indexes

If the direct labor cost to process No. 1 Common lumber is used as a base for comparing costs, the direct labor cost to process the other grades may be expressed as a percentage of the No. 1 Common cost. Costs for any grade could be used for the base; those for No. 1 Common are considered to be most suitable because this grade is used by most furniture factories and

Table 1.—DIRECT LABOR GRADE COST INDEXES BASED ON NUMBER ONE COMMON LUMBER

Lumber Grade	Direct Labor Cost and Cost Index	Cutting Length, inches 12	24	36	48	60	72
FAS	D. Labor Cost*	$.0294	$.0169	$.0136	$.0127	$.0124	$.0124
	Cost Index	.63	.59	.59	.59	.60	.61
Saps	D. Labor Cost	.0364	.0212	.0171	.0160	.0157	.0155
	Cost Index	.78	.75	.73	.75	.76	.75
No. 1	D. Labor Cost	.0467	.0285	.0235	.0214	.0206	.0204
	Cost Index	1.00	1.00	1.00	1.00	1.00	1.00
No. 2 A Common	D. Labor Cost	.0593	.0375	.0301	.0278	.0269	.0267
	Cost Index	1.27	1.31	1.28	1.30	1.31	1.31

*Costs are from a time study of a conveyorized rough mill. They include cross-cut and conveyorized line, and ripping operations. Costs shown are for 1-inch yellow poplar. For other species, Selects costs were almost identical to those for yellow poplar Saps. For other grades of 1-inch lumber, the above costs apply.

[3] Creighton, J. W. 1955. Time study methods for furniture plant rough mills. Forest Products Journal V (5): 337–341.

much of the cost data presently in use by furniture factories is based upon yields comparable to those obtained from this grade.

Table 1 summarizes total direct labor costs to manufacture 1-inch yellow poplar cuttings of 3-inch widths and various lengths.[4] The direct labor cost index by which the costs of processing different grades may be compared are also recorded for each length in each grade. These indexes are found by dividing the direct labor cost for processing No. 1 Common into the direct labor cost for processing each other grade.

The cost indexes as shown are fairly constant within the lumber grades. Indexes average approximately .60 for Firsts and Seconds; .75 for Saps; 1.30 For No. 2A Common Indexes similarly determined for 2- and 4-inch widths in 1- and 2-inch black cherry and in 1-inch hard maple in no case varied more than .03 from the indexes given in Table 1. The Saps grade is not common to other species, but the index for Selects was approximately the same as that for yellow poplar Saps. Otherwise, indexes for other species were the same. Six-inch widths tended to average approximately .05 higher, but the variation in index because of width was negligible.

Indexes at two other furniture plants were found to be almost identical for cuttings 4 inches and wider in width. They were: .64 for First and Seconds; .83 for Selects; and 1.26 for No. 2 Common. It should be pointed out that in these two plants there was considerably more material handling than in the first plant mentioned. Both these plants are characterized by having every process (including cut-off, face planing, sufacing the back face, edge jointing, and rip sawing), hand-fed by one man, picked up on the outfeet end and stacked on a factory truck by another man.

Indexes based upon yields, determined by dividing the No. 1 Common yield per cent by those for other grades, would be as follows: First and Seconds, .77; Selects, .89; and No. 2 Common, 1.22. These would apply to all furniture plants regardless of how the cuttings were processed as long as yield percentages in the various grades were comparable.

Development of Direct Labor Length Cost Indexes

Table 1 also indicates a fairly constant relationship between direct labor costs to produce different lengths. If the 24-inch length is taken as a base and the direct labor cost value for this length is divided into the costs for other lengths, the resulting length cost indexes will be as shown in Table 2.

Length indexes as shown in Table 2 for 6-inch widths tend to deviate from the base length index of 1.00 less than do indexes for narrower widths. Otherwise they remain fairly constant. Other indexes are comparable for 2- and 4-inch widths of 1- and 2-inch thicknesses at the conveyorized plant and 1-inch thickness at the other plants,[5] for Firsts and Seconds, Selects, No. 1 Common, and No. 2 Common grades.

Average direct labor length cost indexes excluding the 6-inch width from Table 2 for the conveyorized rough mill are as follows:

Length, inches	Average Direct Labor Length Cost Index
12	1.65
24	1.00
36	.82
48	.75
60	.73
72	.72

Data collected in the three furniture plants cannot necessarily be applied to other plants without modification. No two plants are exactly alike. Equipment, handling methods, distances between machines, feed speeds of the machines, the power applied to operate the machines, operation sequences, and personnel differ between plants. However, the general function of furniture plant rough mills is the same, and even the sequence of operations tends to vary little from one plant to another.

The methods used here may be used in any furniture plant rough mill as a guide to determine the differences in the direct labor and direct material costs between cuttings produced from the different lumber grades. The procedure for finding the direct labor cost by detailed time studies is somewhat laborious and, for this reason, the use of cost indexes may save considerable time in estimating direct labor costs of cuttings of different sizes produced from different lumber grades.

[5] See footnote 4.

Use of Cost Indexes to Estimate Direct Labor Cost

If the direct labor cost for one cutting size produced from one grade of lumber is known, the cost indexes may be used to estimate the direct labor cost of producing cuttings of any size and from any lumber grade. For example, if the direct labor cost per net foot to make a 24-inch cutting from No. 1 Common lumber is $0.0285 and the cost to make a cutting 60 inches in length from First and Seconds lumber is desired, the direct labor cost to make the cutting will be the product of the No. 1 Common cost multiplied by the length index for 60 inches and grade index for Firsts and Seconds. This is shown as follows for 1-inch yellow poplar at the conveyorized plant:

$0.0285 x .75 x .60 = Direct labor cost per net foot to make 60-inch lengths from Firsts and Seconds 1-inch yellow poplar

= $0.0128 per net foot

Actual cost .0124 from a time study of this cutting size

Error .0004 per net foot

As a second example, if the direct labor cost to produce 24-inch lengths 4 inches wide from 2-inch No. 1 Common black cherry is $0.0169, the cost to produce 12-inch lengths 4 inches wide from No. 2 Common lumber would be:

$0.0169 x 1.65 x 1.30 = The direct labor cost per net foot to make 12-inch lengths from No. 2 Common 2-inch black cherry.

= $0.0363 per net foot

Direct labor costs to produce cuttings of different sizes from the different lumber grades may thus be determined if the cost to produce one size from one grade is known. The work required to find the direct labor cost for the one size in one grade is considerably less than that required for a range of sizes in all grades.

An application of the index method of estimating direct labor cost was conducted in a fourth furniture plant in which the rough mill was not conveyorized. The cut-off saw was a hand-feed ram type and there were no conveyors between any of the machines. Stock was transported on trucks from each operation to the next. A study was

Table 2.—DIRECT LABOR LENGTH COST INDEXES BASED ON TWENTY-FOUR INCH LENGTHS

Lumber Grade	Species	Average Width Inches	Cutting Length, inches 12	24	36	48	60	72
			CONVEYORIZED ROUGH MILL					
Firsts and Seconds	Yellow Poplar	3	1.74	1.00	.80	.75	.73	.73
Saps	Yellow Poplar	3	1.72	1.00	.83	.75	.72	.72
No. 1 Common	Yellow Poplar	3	1.64	1.00	.83	.75	.72	.72
No. 2 A Common	Yellow Poplar	3	1.58	1.00	.80	.74	.72	.71
No. 2 Common	Cherry	2	1.62	1.00	.81	.75	.70	.69
No. 2 Common	Cherry	6	1.58	1.00	.85	.80	--	--
			AVERAGE FROM NON-CONVEYORIZED MILL					
all Grades	Maple		1.71	1.00	.80	.72	.67	.64

Direct labor costs shown are from a detailed time study of a conveyorized furniture plant rough mill. Costs for two plants which were not conveyorized were also determined. (Footnote 3.)

Table 3.—ROUGH MILL DIRECT LABOR COST ESTIMATES

Lumber Grade	Index	Direct Labor Cost, Dollars — Cutting Length, inches: 12	24	36	48	60	72
		1.71	1.00	.80	.72	.67	.64
Firsts and Seconds	.64	.0673	.0393	.0314	.0283	.0263	.0251
Selects	.83	.0872	.0510	.0408	.0367	.0342	.0326
Number One Common	1.00	.1050	.0614	.0492	.0442	.0412	.0393
Number Two Common	1.26	.1322	.0774	.0618	.0557	.0517	.0495
CHECK							
Firsts and Seconds		.0691				.0268	
Number Two Common		.1305				.0506	

made of the direct labor cost to produce solid hard maple cuttings 24 inches and 2¾ inches wide from No. 1 Common lumber. In order to get the net yield per cent from the lumber, cuttings of 15 inches were also made and the total yield was computed on the basis of 15- and 24-inch lengths.

Forty-five boards, totaling 342 board feet, were picked at random from a kiln truck containing 3,750 board feet. Time studies at each operation were conducted in the same way as described by Creighton.[6] The direct labor cost was then computed. Total direct labor cost for all the operations for making the cuttings was $0.0614 per net foot. Direct labor length and grade cost indexes were then applied to estimate the cost of processing other grades and lengths. Indexes from the nonconveyorized plants were used because no conveyor equipment was in use. Estimated costs are summarized in Table 3.

The direct labor cost to produce 12- and 60-inch cuttings from Firsts and Seconds and from No. 2 Common grades were also computed from a time study, to check the estimates, and are indicated in Table 3. The estimated cost and the costs based on time studies of the individual sizes are sufficiently close for most purposes.

If the indexing method of estimating direct labor costs is used, care should be taken that the cost of the base cutting size is accurate. If this figure is erroneous, estimated costs of all other sizes will also be incorrect. The sample size of the cutting dimension upon which the cost indexes are based should be sufficiently large to be representative of the lumber grade and length class.

[6] See footnote 3.

Conclusions

1. The index method of estimating direct labor costs is not as accurate as estimates based on detailed time studies. However, it presents a much more rapid means of determining cutting costs than does a complete time study of all sizes in all lumber grades.

2. There is a more stable direct labor cost per net foot between cuttings of different sizes and between cuttings made from different lumber grades in modernized plants with mechanical material handling equipment than there is in plants where all machines are hand fed. This is indicated by the fact that the less labor put into the rough mill, the less deviation there will be in both length and grade indexes.

3. There is a rapid rise in direct labor cost per net foot with a decrease in cutting length. For example, the direct labor cost per net foot for a cutting 12 inches long is nearly twice that of one 36 inches long.

Significant Factors for Establishing a Particle Board or Hardboard Plant[1]

S. C. ROONEY

President, Columbia Engineering Co. Ltd., Vancouver, B. C.

Factors which must be studied in evaluating the economics of a particle board or hardboard plant are: raw material supply, types of products, marketability, and production equipment required. Basic boardmaking processes are summarized and significant variables which govern product quality and cost are discussed.

Introduction

THE HARDBOARD INDUSTRY has become a well-established part of the U. S. industrial picture and its products have found increasing acceptance and use in domestic markets. It is only recently, however, that a larger cross section of the forest products industry became interested in manufacturing such a product, partly because the necessity for greater log utilization is just beginning to be felt on this continent.

A number of new manufacturing methods have been developed in addition to the original Masonite process to produce fiber board and hardboard. In the last five years, still newer techniques of particle board and chipcore manufacture have appeared on the scene, enabling the operator to utilize a wider range of forest by-products with an increasingly lower capital investment. Today the industry is in a position to utilize almost all its waste materials and to turn them into a wide range of attractive items, some of which have still to gain consumer acceptance. We are witnessing the growth of an entirely new forest product which may, in time, revolutionize the industry and change present concepts of converting logs to consumer goods.

A similar development has been taking place in Europe for some time, mainly because depleted European timber resources have driven manufacturers toward more complete log utilization. In the U. S. and Canada, however, it was not until the end of World War II that the necessity of forest management for perpetual yield and waste utilization became obvious and generally accepted. Since that time, the price of logs has steadily increased because the industry is forced to carry the cost of reforestation, fire prevention, selective logging roads, and all the other activities of good forest management.

The increasing importance of being able to utilize the waste materials of

[1] Presented at Session I, Composition Board, FPRS Ninth National Meeting, June 21–24, 1955, in Seattle, Wash.

The Author: S. C. Rooney is a graduate of the U. of British Columbia. He served as design and project engineer with Aluminum Company of Canada and Watrous Ltd., was on the staff of H. A. Simons on pulp mill design before forming present firm in 1946. The firm has designed and built sawmills, a paper board mill, and particle board plants.

sawmills, plywood mills, and other wood processing plants is obvious. The problem is how to turn these waste products into attractive, saleable items at a cost competitive with other accepted products. Moreover, the application of such products will have to be continually enlarged and new markets explored in order to insure a quantity which will guarantee economical manufacturing procedures. For on the endeavour to turn waste into profit may well depend the future growth of the entire forest products industry and its ability to meet competition from other natural or synthetic products.

To the operator who is looking for ways to convert his waste into saleable goods, there are a number of processes and manufacturing techniques available. Many of these systems have been proven in operation but are limited by the type of waste material they can utilize, as well as their market application.

Other processes, although showing great promise in interesting products, are still in the pilot plant stage and are not yet proven under operating conditions. There are also undeniable difficulties connected with the assessing of the costs and saleability of such products until they are actually manufactured in quantity. There are also a number of processes and systems on the market which have proven their worth in Europe, under European working conditions, and their products have found satisfactory acceptance on European markets. In America, however, both working conditions and markets are entirely different so the economy of such processes and products have to be evaluated in the light of these factors.

The information available from various laboratories, manufacturers of producing machinery, and promoters of various processes is at times confusing and often contradictory. Market information on products now being supplied or on products still in the pilot plant stage is sometimes difficult to obtain and is often vague and incomplete. It can therefore be said that the selection of a certain manufacturing method to utilize wood waste materials, as well as the evaluation of the potential markets for the products, requires a great deal of specialized knowledge and information.

Because of this situation, the following is an attempt to organize the available data concerning fiberboard and particle board plants and offers an approach towards assessing the various factors which affect the conversion of wood waste into composition board. The information given and the opinions expressed are based on the economic analysis of a number of projects and on the actual design and construction of two plants now in operation. It is offered in the hope that it will be of value to operators facing problems of a similar nature.

Factors Affecting Plant Design

Obviously the work on any project has to begin with a study of both the raw material and the end product, or in this case a study of the wood waste in question, its shape, form, quantity, cost, etc., and consideration of what types of product can be made. Moreover, it is not sufficient to be able to make a certain product; its use, application, competitive cost—in short, its marketability—also have to be assessed and the size of the potential market estimated. These problems and all the questions connected with them have to be answered before the actual selection of the manufacturing method and equipment can be started.

It follows, then, that the market for the products and the method of marketing deemed to be most advantageous are likely to have a marked affect on all decisions connected with the project.

In studying the hardboard industry today, it is possible to detect two more or less distinct approaches to the problem of manufacturing and marketing. The first one, which might be called the "plywood approach," endeavours to produce one product of certain density, physical properties, surface characteristics, etc., and to market this product under a trade name. This product may be sold in two or three different grades, such as standard and tempered fiberboard, or interior and exterior grade plywood. Essentially, however, it is one type of general product and no attempt is made to allow for customer specification, except within certain narrow limits. The other approach, which could be compared to that of a specialty paper mill, is to make panels of varying densities, physical properties, and surface characteristics, in order to give each customer the type of panel he requires; in other words, to be able to produce a wide range of products and sell them competitively in a number of markets.

Both approaches have certain advantages and disadvantages and in most cases a general policy is not as clearcut as stated above. Most plants, although designed to manufacture a certain type of product, will vary this product for the sake of a sufficiently large order, if it is possible to do so with existing equipment. On the other hand, a plant designed to turn out a wide range of products will settle down to manufacturing two or three items which the management finds most profitable. Still, at the outset of any project, the decision as to which one of these policies is to be followed will be an important one and will affect the plant design to a large extent.

A flexible, multi-product plant appears most practical unless, of course, market conditions definitely point toward one certain panel type. In most cases, particularly on particle board, the market information available is not conclusive and therefore the ability to vary the product will be found a distinct economic advantage. Furthermore, since it is possible to design such flexibility into the plant at a small increase in capital requirements, this type of approach should be given careful consideration.

Raw Material

There are two basic raw materials required for the manufacture of fiber board or particle board. These are: (1) the fibers or particles, and (2) the various additives required to bind the fiber together and to impart to it various physical characteristics.

The subject of additives is a special study, and should be discussed, if at all, in detail. Furthermore, the manufacturer of a composition board will always strive to restrict their use as much as possible since his primary aim is to utilize wood waste at the lowest possible cost. For these reasons, while fully recognizing the importance and significance of additive type and content on composition boards, the subject is considered to be outside the scope of this paper and the composition board field will be discussed in the light of the other significant factors. This limits this paper to products which can be made with the help of known and readily available additives.

Fiber is obtainable from wood and such other materials as bagasse, straw, etc. For the purposes of this discussion, however, wood will be considered as the basic raw material for manufacturing fiber.

Wood is available in many forms for the manufacture of fiberboard or particle board. Essentially these can be broken down into two classes: (a) logs or logging waste, and (b) mill waste. The important questions are at what cost can any one of these raw materials be put down in the yard of the plant, and what does it cost to manufacture the proper fiber from these various wood forms. In the final analysis we are mainly interested in the cost and quality of the finished fiber. Fiber quality, its strength, and other characteristics determine to some degree the amount of additives required for given board properties. High strength, good

quality fiber means less additives and therefore lower finished costs. In certain cases the cost of manufacturing a certain type of fiber may exceed the saving to be obtained by the reduced resin requirements, in which case there is no advantage to be gained from better raw material or refinements in the fiberizing operation.

Examining the various forms in which wood is available for fibers, it appears that logs and logging wastes constitute the most expensive form in which wood can be purchased. A proposed mill will have to carry all the logging transportation and stumpage costs and will also have to consider the addition of a barker to the plant. There are certain processes which utilize the bark in the finished product, but in the majority of the cases it will be found advantageous to eliminate the bark and utilize clean wood for board manufacturing purposes. Furthermore, there are storage and yard handling costs connected with logs and logging waste which further add to the overall cost of this raw material.

Mill waste can be purchased in many forms, which can be broken down into the following classifications: (A) Sawmill or plywood mill waste (slabs, edgings and veneer waste); and (B) Machining waste (planer shavings, turnings, etc.) These wastes can be purchased at a much lower price per ton of fiber than whole logs or logging waste, since the mill which did the original processing has already paid for the cost of logging, transportation, etc. Some of these raw material forms such as planer shavings and turnings are only usable as fuel and will therefore command a low price. Others such as slabs and veneer waste are suitable for manufacturing pulp chips and will have to be purchased in competition with pulp mills. This, of course, is only true for species desirable for pulping and if a pulp mill is reasonably close to the site of the plant generating the waste. Thus in most cases there is a good supply of reasonably priced chips available to a suitably located board plant.

If there is a choice of the various waste materials, it is advantageous to employ a form from which a long and strong fiber can be manufactured. The use of "chunk" material will result in unbroken long fibers and will therefore be given a certain priority. Slabs, edgings, and veneer waste constitute such chunk material and can be chipped or otherwise shaved to supply pieces containing unbroken fiber for further fiberizing operation. On the other hand, shavings produced by planer mills will have most of the fiber already damaged to a certain extent and will therefore have limitations in board production.

The slabs available from sawmill operations usually have to be barked before further processing. Often it is possible to persuade the sawmill to install a log barker, if the slabs only can be sold bark free since barking will result in added economy in the sawing operations. At any rate, even barky slabs are usually cheaper to purchase and process than whole logs.

Veneer waste is probably the most suitable material for board marking since the bark has already been removed and the chips obtained from this material will be of fairly regular size and constant thickness. They will therefore give a particle or fiber of close classification.

Shavings obtained from certain machine turning operations constitute an excellent, long, fibrous material especially suitable for the manufacture of particle boards; however, the quantity in which these shavings can be obtained is usually quite limited. Planer shavings, on the other hand, are in ample supply but have the disadvantages mentioned above. A number of projects still see fit to utilize these planer shavings in spite of the added resin cost, mainly because the reduced cost of the wood fiber helps offset the added resin costs or additive costs for a given product.

The cost of manufacturing fiber from these various wood wastes also has to be considered. Generally speaking, turnings and shavings, which are already broken down to a large extent, can be processed into a suitable fiber with less horsepower and handling costs than slabs or veneer wastes.

The Product

There are a sufficient number of well-established composition boards on the market to give an idea of the product range available by the use of proven manufacturing methods. Most of us are familiar with Masonite and similar screenback type of hardboards which are available either tempered or untempered, or the two-sides-smooth hardboards produced by U. S. Gypsum Co. and others. In the same density range but having slightly different properties, Resinwood and Lebanite have also found customer acceptance. In the lower density range are panels like Novaply with a special decorative surface; Plaswood; the boards made by Mississippi Wood Products, and a number of other core boards as well as some extruded products. All of these are produced in quantity and are finding a ready market.

These examples illustrate the range of products actually manufactured on this continent. There are a large number of plants in Europe manufacturing a variety of interesting panels in a wide range of thicknesses and densities. Moreover, laboratories and pilot plants are working on a number of products which might be manufactured more economically for given physical characteristics than the ones now on the market.

What are the properties of composition boards compared to solid wood or plywood? Almost all the physical characteristics of wood or plywood can be equalled or even exceeded but not at the same density. In other words, a composition board having the weight of wood will possess certainly lower strength characteristics and at best will be equal to wood in various other aspects. It may not warp like wood or plywood but it probably will be less resistant to moisture. So, if weight is the primary consideration, a composition board will be considered inferior to natural wood except perhaps as an insulation material. However, composition boards can be produced at the density of plywood which have sufficient strength and other characteristics for certain applications. For instance, a core material can be produced cheaper than plywood. If it is acceptable to raise the density of a particle board slightly over that of plywood to 0.7 or 0.75 specific gravity, in strength the particle board will approach plywood and will exceed it in water absorption, dimensional stability, nail holding, screw holding, edge characteristics, and machinability. Furthermore, the cost will still be below plywood costs.

In the high density range, there is the choice of either low cost utility panels or certain specialty products capable of meeting the most stringent specifications. The cost will depend on many factors but in most cases will compare favorably with that of plywood.

Although research laboratories are constantly striving for a composition board that will equal plywood's strength at plywood's weight, the significance of this ideal is questionable. Plywood is not exactly like lumber and it has still found a large market due to its suitability or overall cost advantage in a given application. Hardboards and particle boards, because of certain properties or cost, have already found a wide range of markets either in competition with other wood products or entirely divorced from them. Therefore, the question of cost versus product specifications in any given case would seem to be much more significant than any general comparison with wood or plywood.

There are, of course, certain limitations to the types of products which can be made from a given form of raw material. For instance, the use of planer shavings will result in an excellent high density board with good surface and strength characteristics but in most cases will not give as good low density panels as those manufactured from material forms which can be broken down into strong and controlled fibers or particles. On the other hand, a larger, longer, and tougher fiber, especially in the case of certain brittle species, will result in poor board surfaces and will yield no particular advantage if surface smoothness is necessary in the desired product. Certain species readily lend themselves for the manufacture of some products but cause exorbitant production costs when used as raw material for others.

If the problem is the utilization of a certain waste product, it is not difficult to determine the product range which can be produced. Similarly, if a certain product is to be manufactured, it is possible to determine the most economical raw material.

Markets

The question of marketability is difficult to answer as for most of the possible products the markets are only partially established. Certain applications for a product can be forseen and its suitability for a certain use established, but it is difficult to predict acceptance by the customer and the speed with which the prospective customer's production methods can be changed to show the new material to good advantage.

For certain established hardboard products, the market is well established and it is comparatively easy to assess whether the existing or projected demand justifies the erection of a new plant. Similarly, some chipcore boards have pioneered certain markets and established themselves in the tabletop field (in combination with melamine laminates); in the cabinet industry, for use as furniture core; and in various paneling applications either with their original surface or overlayed with veneers. These uses, however, are only the beginning. Laboratory tests on various boards have shown that they are at least as suitable in a large number of applications as presently used materials, and that they can be produced at more than competitive costs. The spectacular rise in plywood sales during the past 15 years gives an idea of the market potential for new products.

In many cases, by establishing the actual product specifications, it is seen that the materials now used possess physical properties in excess of the requirements, and that a composition board designed for this use can be supplied at a much lower cost. In other cases, it will be found that materials are now used because there is nothing else available and that because of a more suitable quality, a certain type of composition board will demand a premium price.

The establishment of the actual product specifications of the proposed markets will greatly aid the designer in selecting the process and the plant. For this reason, the data supplied by a detailed market survey will supply valuable information to the planners of such a project and will result in the proper selection of equipment and efficient plant operation.

The Process

Weighing all the significant factors of available raw materials, the product which can be made from them, and the extent of the markets results in a certain range of products which can be sold in sufficient quantities. The engineer can then select the production method, the plant, and the equipment to manufacture these products economically. From this plant design he can accurately estimate the production costs and the profit potential of the proposed operation. There are a number of proven processes or production methods suitable for manufacturing composition board products. These can be broken down in the following categories:

1. Fiber board processes—(a) The wet process producing a 1/8 to 3/8-inch thick screenback type of hardboard; (b) semi-dry process for the manufacture of a similar product; (c) dry fiber process; or (d) the repressed soft board process for the production of two-sides-smooth hardboards, usually up to 3/8-inch thick.

Most of the plants employing one of these processes produce standard hardboards having a specific gravity of approximately 1.00 or over, although some of the semi-dry or dry process plants manufacture lower density panels as well.

All fiberboard processes are characterized by the extremely fluffy fiber they employ. This is usually obtained by exposing standard pulp chips to a fairly short cooking cycle and then fiberizing in a disc-type attrition mill.

The difference between these processes is mainly the type and length of cooking cycle employed, type and amount of additives utilized, techniques of forming the mat, and amount of moisture contained in the mat at the time of forming and pressing.

2. The various particle board processes can be classified by the type of particle they utilize, such as: (a) granular particle; (b) random particle; or (c) controlled dimension particle.

Each of these processes falls in the dry class since the moisture content of the fiber at the time of forming and pressing does not exceed 15% and is more often 10% to 12%.

By these methods, boards can be produced from 1/4-inch up to 1 1/2-inch thickness or even thicker and ranging in specific gravity from approximately 0.50 to 1.00.

Processes employing granular type particles usually utilize shavings or other fairly fine waste materials, and obtain the fiber either by a fine hammermilling operation or by dry grinding, as in an attrition mill. The resulting product is usually of the high or medium high density type (above 0.85 specific gravity), since the fiber does not possess sufficient inherent strength to be suitable for low density applications.

The term "random" is applied to particles which are obtained by hammermilling hogged or chipped slabs or veneer waste, since this method does not give an effective control over the size and shape of particle obtained. These random particles are usually screened to eliminate the under- and over-size material to give some regularity and classification in the particles to be used for further processing. Most chipcore or coreboard operations follow this method and some produce high grade panels in a specific gravity range from 0.55 to 0.95.

Controlled dimension particles are produced on specially designed machines and utilize debarked slabs or pulpwood, veneer waste, or other bark free chunk millwaste of certain limited dimensions. This method enables the operator to control accurately (within the adjustment range of his machine) the length, width, and thickness of the particles, thereby obtaining a closely classified material. Generally these particles can be cut as square flakes or wafers, or in an elongated form, the thickness being closely controlled in all cases. Since the cutting action is performed along the grain of the original piece of wood rather than across the grain as by a conventional pulp chipper, the fibers retain most of their original strength which in turn is said to reduce the synthetic resin requirements for a given board density and physical properties.

Laboratory tests indicate that this type of fiber is superior to hammermilled particles but presents certain difficulties in the blending and felting operations. Moreover, the machines designed to cut such fiber and the plants and processes based upon them are still in the experimental or pilot plant stage on this continent and have not

been proven under actual operating conditions.

Most of the European plants producing "Spanholz" type panels utilize some controlled domension particles. However, the cost of producing these particles is difficult to obtain, nor can the claimed savings in resin costs be accurately checked from this distance. It would seem, therefore, that the economic foundation of such processes is yet to be proven and it is expected that current pilot plant operations will yield this data.

The above classification of the various processes is based mainly on the type of fiber or particle utilized. There are, of course, other differences, such as the type and quantity of additives employed for board consolidation, method of felting or material pressing techniques, etc. However, the type of fiber determines the basic character and the significant limitation of any process, providing the best basis for comparison. Almost any of these processes is workable with different resins, sizes, etc., but it is usually the fiber characteristic, density, and type of product desired that determines the type and amount of additives to be used.

Possibly a further classification could be made in the particle board field as a function of the pressing operation. All processes mentioned above assume multiple opening hot plate pressing. There are a number of processes which employ either a continuous press or an extrusion machine for board consolidation. However, these processes can be grouped under the heading of particle boards. The appearance, if sometimes not the physical properties of the end product, is still determined by the type of fiber employed.

Some of the manufacturing methods, or certain important parts thereof, are protected by patents and are either not available or demand a certain royalty from the prospective operation, while others are available for general use. Assuming that either an "open" system is being considered, or that a satisfactory arrangement can be made for patented processes or machinery, the designer has the above range to choose from. He will probably find that given a certain end product, more than one method will serve his purpose. For instance a $\frac{1}{8}$- to $\frac{3}{8}$-inch thick, high density (1.00 specific gravity), two-sides-smooth board can be produced either by the dry fiber process, the repressed soft board process, or the granular particle board process. Both the wet process and the semi-dry process will produce a standard hardboard. A medium density coreboard may be produced from random or controlled type of particles, either pressed in a multiple opening press or extruded, or possibly arrived at by the dry fiber process. The availability and cost of raw materials, the detailed specification of the end product, operating experience with an existing installation, information gained from pilot plant tests, and the overall economy under a given set of conditions will gradually narrow the choices and lead to a final decision.

In most cases it will be found that no single process will apply to a set of given conditions and that certain parts of the flowsheet or even some individual machinery will have to be changed to give the desired product or to utilize the raw material at hand to best advantage. It is highly probable that no two plants can be exactly alike and that each project will demand a special flowsheet, re-examination of each stage and each piece of equipment, and certain amount of research work on additives, pressing cycles, pressures, and temperatures most applicable to the fiber and product in question.

The Plant

After a process is chosen, it is necessary to apply sound engineering principles and careful thinking to all problems, from selection of individual pieces of equipment, plant layout, and building requirements, to the last piping or electrical detail. The problems of wood handling and storing, conveying, chipping, hogging or hammermilling will be familiar to any lumber mill operator and the selection of equipment and layout for these can be based on past experience. The difficulties of storing and feeding fibrous materials will be appreciated by those concerned with chip and hog fuel storage.

There are a number of special problems confronting the designer of a hardboard or particle board plant which are characteristic to the operation and which will have to be solved satisfactorily if the plant is to produce a consistently homogeneous product.

The preparation of boards in a laboratory by hand will stress the great number of variables that affect the physical properties of a hardboard or particle board. One of the most important lessons to be learned from labortory work is that small variations in moisture content, fiber characteristics, pH of the raw material, or blending or forming procedure often outweigh the effects of resin or size content, or other variables which are being investigated at the time. A few checks on the density distribution of the finished board will show the importance of accurate forming methods.

In the laboratory it is possible to control some of the variables to a lesser or greater degree, put up with some others, and compensate for errors in the test results. In a production plant, however, certain minimum control requirements have to be met if one is to turn out a homogeneous product with reasonably consistent physical characteristics.

The following are the control requirements which should be incorporated or striven for in an efficient plant design.

1. Moisture control: (a) The moisture content of the raw material has a significant effect on final fiber characteristics and fiber classification, regardless of the type of fiberizing equipment employed. Furthermore, the moisture content of most wood waste materials, except those generated from kiln-dried lumber, will vary with the seasons, the weather, and other factors. For these reasons, means should be provided to at least inform the operators of the variations and preferably to make either manual or automatic moisture compensation possible.

(b) Moisture content affects both the weight and the bulk density of the fiber or particle. Therefore, at any point in the plant where it is necessary to feed fiber accurately, either volumetrically or gravimetrically, a satisfactory method for recording and correcting moisture will have to be provided.

(c) The moisture control of the fiber or particle at the time of blending will have a marked effect on resin penetration and resin adhesion. Therefore, one should be in a position to control moisture at the point of blending.

(d) The moisture content of the fiber mat immediately prior to pressing will govern to a large degree the required pressing times, temperatures, and pressures, as well as the resulting board characteristics. Moisture indication and control at this point of the operation is essential.

(e) Means should be provided to control the moisture content of the finished product for purposes of stabilization.

2. Fiber Control: The character and classification of the fiber or particle have an important bearing on a great number of board characteristics. Effective control of the finished product is almost impossible without some control over the fiber particle. It follows that the fiberizing machinery should be capable of consistently producing a fiber or particle of a certain character within certain classification limits, o that equipment should be provided for rejecting the undesirable materials Since most available equipment suitable for classifying fibers or particles is of limited efficiency and effectiveness, it will be necessary to install ma

chinery which will fiberize within the required classification limits (for instance, attrition mills in fiberboard plants).

3. **Feed Controls:** The additives and fiber should be blended in the correct proportions, not only for control over board characteristics, but for economy. Since the bulk density of the fiber or particles will vary in a relatively short time interval, and since the blending proportions are based on weight rather than volume, a volumetric fiber or particle feeder (especially for the manufacture of particle boards) will be found inaccurate. A gravimetric feeder will give more satisfactory control in most cases. Resins, sizes, and other additives, especially if supplied in a liquid form, have a sufficiently constant density and can be fed volumetrically with constant volume pumping equipment.

A continuous operation is preferred to the batch system because of operating ease and reduced labor requirements.

4. **pH Control:** The effect of wood pH on board characteristics and other phases of the operation is finding increasing recognition among research workers and operators. Means of controlling the pH will be an advantage in most cases and a distinct necessity in others.

5. **Blending or Coating:** This is one of the most important operations of hardboard and particle board manufacture. An even distribution of the additives is not only a prerequisite for producing a homogeneous product continuously, but will also result in greater economy by reducing the additives required for certain board characteristics. The ideal to strive for is that each fiber or particle should be evenly coated with an infinitely thin film of resin or any additive being used. Such film will suffice for bonding or sizing the fiber efficiently and any greater amount of additive deposited on any particle is wasted. This ideal is not easy to reach although some coating methods used today come sufficiently close to result in a satisfactory operation. Here again, in most cases, continuous blending or coating has certain definite advantages over a batch system and will generally result in a more consistent end product.

6. **Forming or Felting:** All the accuracy and control earlier in the process is lost if the coated fiber is not formed in a mat of even weight distribution. Accurate volumetric feeding will not suffice since, as mentioned before, momentary variations in the bulk density of the material will cause high or low density spots in the finished product, no matter how level the mat may appear. Furthermore, a mat perfectly level on the top surface does not mean satisfactory distribution, even volumetrically speaking, since the caul, tray, or rubber belt upon which the mat is deposited usually is not perfectly level. Neither will it suffice to know that each individual mat weighs the same. This is only a primary prerequisite. An even weight distribution of the material throughout the mat is much more significant, since a slight density or thickness variation between individual mats is a lesser evil than density variations within a single panel. It is to be noted that the rate of moisture pick-up of the finished product is largely a function of density at any given additive content. If the panel is allowed to absorb more moisture in one spot than in another, it will inevitably warp and not be as saleable an item.

Not only should the weight of the fiber be evenly distributed throughout the mat, but each cubic inch and each cross-section and surface should be composed of the same type and classification range of fiber. Most types of fiber tend to classify themselves when falling; also the finer particles have a tendency to gravitate to the bottom of the mat, leaving the coarse material on the top. This phenomenon will be aggravated if the mat is not handled with utmost care between the forming apparatus and the press. Prepressing the mat immediately after forming helps to eliminate some of this tendency; still, any degree of difference in fiber classification between the two surfaces of the mat will cause differences in surface density and strength characteristics of the finished panel, which will again lead to warping.

Another phenomenon to guard against is that of fiber orientation. This will result in difficulties during the pressing operation and will cause a certain "grain" in the finished product.

A 100% even weight distribution and a 100% even fiber classification throughout the mat is difficult, if not impossible, to attain. However, ideal conditions are not necessary in a practical operation as long as density and fiber variations can be kept within certain limits which will assure a dimensionally stable end product. There are a number of forming machines or felters in operation today which are capable of forming a mat within satisfactory operating tolerances. Most felters or forming machines are designed for a certain process and will be found satisfactory only when used within narrow limits.

7. **Pressing:** A multiple opening hot press is a standard piece of industrial equipment and can be purchased from a number of established manufacturers in a wide range of sizes and other specifications. However, a press with its hydraulic pumping unit, designed especially for consolidating hardboards and particle boards, must have certain stringent characteristics since it constitutes the final control point in the manufacturing operation.

The essential functions a press must perform in any hardboard or particle board process can be summarized as follows:

First, the press must compress the mat to the desired thickness with the most desirable pressure cycles required by the particular product or products in question. The hydraulic unit should be designed to close the press and bring it to maximum pressure in the shortest possible time, and to release the pressure either according to a present cycle or as governed by the board thickness. Although it is essential that the hydraulic system be operated by a completely automatic timer according to a certain cycle, hand controls should also be provided.

The maximum pressure to be exerted by the press for any given product can be determined by laboratory tests. However, it is wise to consider all possible products the plant might produce in the future before deciding maximum pressure requirements. A press capable of 100 psi greater specific platen pressure means only an insignificant increase in total capital requirements and gives the plant a flexibility which may prove to be of great importance.

Second, the press must transmit heat to the mat to set the adhesives and to evaporate moisture. The operator should have accurate control over the temperature of the platens and the design should provide for a completely uniform heat distribution over the entire platen area. Whatever means is used for supplying the heat, local and momentary heat demands caused by moisture variations in the mat should be satisfied promptly and efficiently. Means should be provided, whenever possible, to indicate temperatures at several points on each platen to check the heat distribution.

Third, the press not only serves to consolidate the mat and to set the resins, but also determines the finished product thickness. Pressed boards can be overthick and corrected by either a planer or sander, since usually these machines will be required to impart certain surface characteristics to the product. Accurate thickness control in the press means less work to be done on the finishing equipment with less waste.

For these reasons, the press platens should be accurately machined and should be of hard metal which will remain flat after years of service. Furthermore, the ram table must remain

horizontal during the entire closing cycle to assure uniform pressures over the platen areas.

If the above conditions are fulfilled, the actual thickness of the product can be controlled either with the help of a platen stops or by stopping the movement of the ram table at a given point with the hydraulic system. In some cases, especially in the manufacture of high density products, a certain predetermined pressure cycle will result in a sufficiently accurate finished thickness without any other added control.

There are other features of the press which warrant careful consideration. The various design details, operating and maintenance characteristics, and other pertinent data can be judged by the usual engineering considerations. Special attention should be given to the daylight available between press platens and the actual dimensions of the platens. The available daylight restricts the operator to a production of certain thickness and the maximum possible board thickness should be carefully investigated before this feature is finalized. As to the size of the press, most operations to date are based on either the 4- x 8-foot or the 4- x 16-foot, product dimensions following the precedent set by plywood and the requirements of the construction industry. In a great number of cases, however, a large percentage of the output will not be sold in the construction field so it is highly possible that certain other press dimensions would prove to be more applicable and would result in less waste after cutting to the customer's requirements. This point requires special study in each given case, as data available at the present does not permit generalization.

During recent years, a number of plants have been erected which consolidate the mat in an extrusion machine and are operating continuous presses for the manufacture of certain types of boards. All of these machines are of special design and are usually connected to a certain type of process. Their worth and applicability can only be judged in a given case by the type and cost of panel they are capable of producing.

Conclusions

1. There are many engineering problems confronting the designer of a hardboard or particle board plant, in addition to those summarized. These problems can be solved in a manner consistent with standard plant engineering practice. The operations and controls specifically mentioned are characteristic of a board plant and represent the primary functions such a plant has to perform. The merits of any board plant or any board process can be judged in the light of how well these functions are performed and how closely the ideal control of the variables is approximated.

2. The study of such a plant must begin with the raw material, the product, and the marketability of this product. Data gained from such study will lead to selection of a certain process and a certain plant design. The two basic approaches to the marketing of composition board panels are outlined as having a marked effect on equipment selection and plant design.

3. The processes or manufacturing techniques available for producing a composition board are classified according to the type of fiber utilized. No single process or type of plant can be considered as a standard solution applicable in all or most cases. Each new project is different and will warrant special study and a special flowsheet. Individual consideration should be given to every piece of equipment.

4. Finally, certain primary functions and control features have been established as an essential part of any plant. The ability of a plant to perform such primary functions, and to approximate the ideal control conditions, can be used as a yardstick for judging its merits.

Discussion

H. John Knapp (Grenco, Inc.): You mentioned particle boards developed in Europe. Have you visited any of these plants and, if so, which process in your opinion is the most desirable for American adaptability?

Mr. Rooney: No, I have not visited any European plants. Some very important work is being done with European techniques. Basically, the use of any European process will depend on how it will fit in with the North American economy. In the first place, our labor conditions are diametrically opposed to those in Europe. Also, they have limited supplies of raw materials which are often difficult to obtain. In selecting any European process to be used in North America, we would have to assess the difficulty of accumulating raw materials there and we would have to assess the resin percentages. European processes are actually using resins in higher percentages than we contemplate using. Finally, we would have to assess manpower requirements in considering adoption of any European process. To summarize, each process would have to be examined individually and all these factors taken into account.

F. Rebick (Ontario Hardwood Flooring Co.): You mentioned two problems—stability and weight—in manufacture of hardboard. In Europe many companies are manufacturing flax boards and similar types of boards. Is there any mixing of wood and vegetable fibers in this country?

Mr. Rooney: No, we have been dealing with single fibers and don't contemplate use of composite materials in the immediate future. Unless costs were extremely low and materials were readily available, it would be wisest to stay clear of composite materials. Weight of the product and shipping costs would also be necessary considerations. We have had no experience with low density boards of composite materials.

The Effect of the Oil Carrier on the Performance of Pentachlorophenol-Treated Wood in Ground Contact Exposure[1]

F. J. MEYER and R. M. GOOCH

Biochemical Research Department, The Dow Chemical Co., Midland, Michigan

Data are presented to show the effect of the oil carrier on the performance of pentachlorophenol-treated wood in ground contact exposure. In general, results on pressure-treated test stakes show that the effectiveness of the treatment increases as the distillation range of the oil used is raised.

Introduction

PENTACHLOROPHENOL IS BEING APPLIED to a wide variety of wood products to preserve them from decay and insect damage. This wide range of utility is due to the fact that pentachlorophenol is a crystalline organic chemical that can be dissolved in a wide range of solvents. The types of products treated fall into three main categories, each of which involves a different type of carrier.

Items such as millwork and lumber are treated with pentachlorophenol dissolved in a solvent or mixture of solvents with a flash point of approximately 105° F. Usually water repellent solids are included to give the treated wood a measure of water repellency. The principal requirements of the solvent are that it shall dissolve the required amount of pentachlorophenol and shall volatilize from the treated wood in a relatively short time, leaving a clean paintable surface.

Products such as utility poles and fence posts are treated with pentachlorophenol dissolved in an aromatic petroleum such as No. 2 or No. 3 fuel oil. The carrier in this case must dissolve the required amount of pentachlorophenol and must have a sufficiently high boiling range so that the non-volatiles left in the wood prevent crystallization or blooming of pentachlorophenol on the surface. In addition, oils of this type leave the wood relatively free from bleeding or oil exudation.

Railroad ties are items which are treated with pentachlorophenol dissolved in a very high boiling point or residual type petroleum carrier. In this application, a high percentage of non-volatiles or residue is desirable in that cutting or shattering of the tie by the tie plate is minimized. Also, the high residue carrier slows down the absorption of water by the tie which in turn minimizes the formation of cracks and checks.

An important point when considering the many types of carriers used with pentachlorophenol is the effect of these oil carriers on the preservative properties of the pentachlorophenol-treated wood. Experiments were initiated in 1947 to obtain information on this subject. The purpose of this paper is to give data obtained over the past several years on the effect of the oil carrier on the performance of pentachlorophenol treated wood in ground contact exposure.

Field Exposure of Test Stakes Treated with Pentachlorophenol and Various Oil Carriers

Test stakes were installed in 1948 and 1949 to determine the effect of the oil carrier on the performance of pentachlorophenol as a wood preservative. In 1948, the U. S. Forest Products Laboratory, in cooperation with The Dow Chemical Company and the Chapman Chemical Company, pressure treated southern yellow pine sapwood 2 x 4's (nominal) with pentachlorophenol dissolved in 12 different petroleum solvents. Retentions were four pounds per cubic foot of a 5 per cent solution of pentachlorophenol in various oils. For comparison, stakes were treated with high residue coal tar creosote. Ten replicates of each treatment were installed in test plots at Bogalusa, La., and at Saucier, Miss., in April 1948. The test stakes were 18 inches long and were set in the ground vertically to a depth of 9 inches. The results of this test are being reported periodically by the Forest Products Laboratory (1).[2]

The test stakes have been inspected cooperatively each year by personnel from the Forest Products Laboratory, The Dow Chemical Company, and Chapman Chemical Company. Table 1 gives the results of inspections made in 1954 expressed as per cent serviceability.[3] The characteristics of the petroleum solvents and the creosote used in the 1948 test are given in Appendix I and II, and the distillation curves for the 1948 solvents are shown in Fig. 1.

The per cent serviceability figures given in Tables 1 and 2 represent the average grade of 20 stakes, 10 in each of two test plots.

In 1949, personnel of the Biochemical Research Department of The Dow Chemical Company pressure treated

[1] A contributed paper.

Authors: F. J. Meyer received B.S. in Chemistry from U. of Michigan, joined The Dow Chemical Co. in 1939 and has been working in industrial preservation field since 1940. He is now Group Leader in Biochemical Research Dept. Meyer is a member of FPRS, AWPA, and ACS.

R. M. Gooch received B.S. in Chemical Engineering from U. of Michigan, joined Dow in 1[illegible] and has been working in wood preservation field since 1947. A chemical engineer in the Biochemical Research Dept., he is a member of ACS and AWPA.

[2] Numbers in parentheses refer to literature cited.

[3] The per cent serviceability figures are arrived at by making use of the log base scale grading system approved by the American Wood-Preservers Association as a standard in 1954. Each stake is inspected carefully for decay and termite attack and its condition is expressed numerically as follows:

Condition	Log Base Scale Grade
No evidence of decay and no attack by termites	100
Localized superficial decay and/or slight termite attack	90
Slight, but positve decay and/or moderate termite attack	70
Deep or severe decay and/or severe termite attack	40
Failure, almost complete loss of strength, due to decay and/or termite attack	0

In the case of the 1948 test, the Forest Products Laboratory reports results on a different basis than above (1). These data have been converted by the writers in arriving at the percentage values in Table 1.

Table 1.—1948 STAKE TEST

Oil Carrier	% Pentachlorophenol in Treating Solution, by Analysis	Average Absorption Lbs./ft³	Lbs./ft³ Dry Pentachlorophenol in Borings*	Average† % Serviceability After 6⅔ Years Exposure at Bogalusa, La. and Saucier, Miss.
Enjay Solvent No. 2	5.0	4.2	0.12	36
	---	4.04	----	0
Stoddard Solvent	5.2	4.06	0.17	47
	---	4.04	----	0
No. 2 Fuel Oil	4.7	3.94	0.18	56
	-	4.08	----	0
Heavy Thermal Side Cut No. 105	5.0	4.02	0.17	46
	-	4.2	----	0
No. 200 Diesel Oil	4.8	4.02	0.13	60
	-	3.96	----	0
Catalytic Gas Base Oil	4.8	4.02	0.15	79
	-	3.9	----	32
No. 300 Fuel Oil	4.9	4.12	0.15	75
	-	4.28	----	33
No. 400 Fuel Oil	4.7	4.18	0.14	58
	-	4.2	----	6
Light Gas Oil No. 102	5.2	4.08	0.17	67
	-	4.14	----	13
Denver No. 3 Oil Blend	5.0	4.02	0.15	77
	---	3.98	----	22
Heavy Gas Oil No. 101	5.2	4.08	0.16	93
	-	4.02	----	65
Lube Oil Extract No. 465E	5.1	4.22	0.15	82
	-	4.12	----	67
Coal Tar Creosote, High Residue	---	4.12	----	72

*Average of 3 borings, one from each of 3 replicates at Bogalusa, La. test plot. Borings taken 1 yr. after installation of stakes.

†Average of 10 replicates at Bogalusa, La. and Saucier, Miss. test plots.

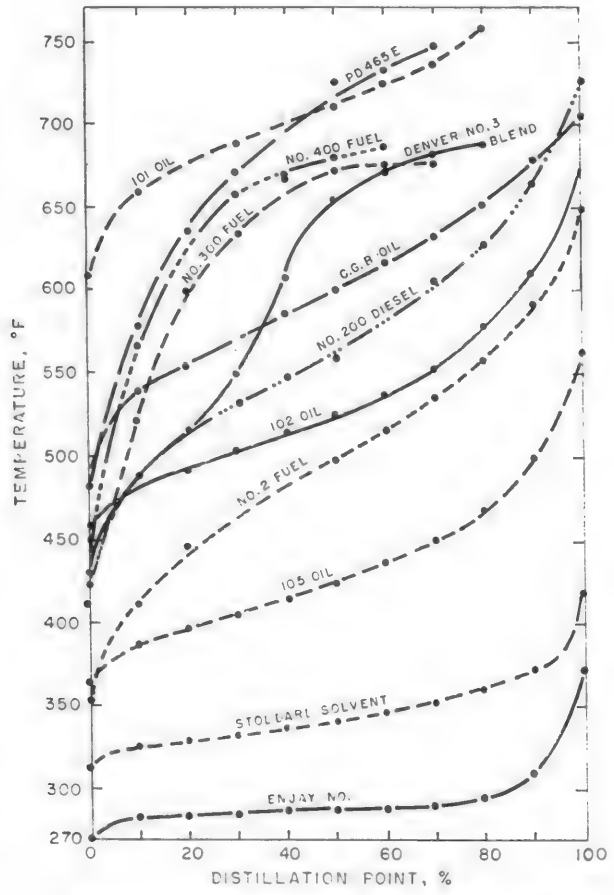


Fig. 1.—Distillation curves of pentachlorophenol solvents in 1948 stake tests.

¾- x ¾- x 18-inch southern yellow pine sapwood stakes with a 5 per cent solution of pentachlorophenol in four oil carriers of varying properties. Retentions of 2, 4, 6, 8, and 12 pounds of treating solution per cubic foot of wood were obtained. All stakes were treated by an empty cell pressure process using either the Lowry or Rueping methods. Ten replicates of each treatment were installed at Bogalusa, La., in November 1949 and at Lake Jackson, Texas in December 1949. Table 2 gives the condition of the stakes after the 1954 inspection. Appendix III gives the properties of the petroleum solvents used. Distillation curves for the four solvents are shown in Fig. 2.

In several instances, the test stakes installed in 1948 showed bleeding or exudation of the preservative. In the case of the very light solvents such as Enjay No. 2, crystallization or blooming of pentachlorophenol on the surface of the wood was noted at the time of installation. There was some reason, therefore, to believe that the test stakes did not have as much preservative as originally calculated.

To obtain information on this point, three stakes from each set of ten replicates at Bogalusa, La., were bored at the midpoint of the section of the stake exposed above ground. A single boring was taken and the entire boring analyzed for pentachlorophenol. These borings were taken in 1949, one year after installation, after any bleeding

Table 2.—1949 STAKE TEST

Preservative Solution	Average* Absorption Lbs./ft³	Average % Serviceability After 5 years in Bogalusa, La. and Lake Jackson, Texas
5% Pentachlorophenol plus 3% Ester Gum plus 92% Enjay No. 2	1.9	0
	3.8	2
	6.1	4
	7.9	6
	11.7	25
5% Pentachlorophenol plus 95% Panalene SN	1.9	4
	4.0	16
	5.9	34
	8.2	57
	12.0	60
5% Pentachlorophenol plus 95% Light Gas Oil No. 102	2.1	4
	4.0	30
	6.0	35
	8.2	51
	11.8	52
5% Pentachlorophenol plus 95% Heavy Gas Oil No. 101	2.3	21
	4.0	60
	5.9	61
	7.8	79
	12.1	85
Enjay No. 2 Ester Gum Control	20	0
Panalene SN Control	6	6
	11	38
Light Gas Oil No. 2 Control	6	0
	16	2
Heavy Gas Oil No. 101 Control	6	41
	13	71
Untreated Wood		0

*Ten replicates of each treatment were installed in each test plot.

and crystallization of preservative had terminated. It should be pointed out that the results of the analytical work which are given in Table 1 do not represent the average absorption of pentachlorophenol in the test stakes. However, since the borings were taken at the same location in each test stake and since three replicates were tested, the analytical figures are considered relative.

Discussion of Results

The results obtained in the two series of stake tests show that the service life of pentachlorophenol treated wood when in contact with the ground is influenced to a considerable degree by the petroleum solvent. Since this is the case, a careful analysis of the properties of the oils used is in order to determine which characteristics contribute most to the preservative treatment.

Distillation Range: An examination of the data reveals that the per cent serviceability in Tables 1 and 2 is influenced considerably by the distillation range of the solvents.

Fig. 2 which pertains to the 1949 test illustrates this effect most clearly. The best results were obtained with Heavy Gas Oil No. 101. For example, after four years exposure in the ground, the stakes treated with 4 pounds of 5 per cent pentachlorophenol in Heavy Gas Oil No. 101 per cubic foot of wood are in better condition than those treated with 12 pounds of 5 per cent pentachlorophenol in Enjay No. 2 or 8 pounds of 5 per cent pentachlorophenol in Panalene SN or Light Gas Oil No. 102.

Good performance was obtained with pentachlorophenol in Light Gas Oil No. 102 and Panalene SN. The distillation pattern of these two solvents are very similar and the serviceability ratings of the test stakes at the various retentions are very similar. Poor performance in ground contact was obtained with pentachlorophenol in an extremely volatile solvent, Enjay No. 2, a commercial product containing largely xylene. The treating solution contained 3 per cent by weight ester gum to prevent crystallization of pentachlorophenol.

The results of the 1948 stake tests show the same general trend. The best performance is obtained with the high boiling solvents and the poorest performance with the highly volatile solvents. To be more specific, the stakes treated with pentachlorophenol in Enjay No. 2, Stoddard solvent, and Heavy Thermal Side Cut No. 105 show serviceability ratings which are low in comparison with high residue creosote. In contrast, stakes treated with pentachlorophenol in high boiling solvents such as Heavy Gas Oil No. 101 and Lube Oil Extract No. PD465E are in the best condition, with serviceability ratings higher than high residue creosote. The large group of solvents in between show a trend in the direction of the heavier solvents giving the better performance.

An exception to this pattern is the performance of pentachlorophenol in No. 400 fuel oil. From the distillation range information, excellent performance would be expected with this oil; the relatively poor ratings obtained are probably due to the unsatisfactory penetration observed at the time of treatment obtained with this oil. The unsatisfactory penetration may have been due to the very high viscosity of the oil. Pure culture tests by Duncan and Richards (2) also show inconsistent results with No. 400 fuel oil.

In the 1948 test, high residue creosote was used as a reference material. As will be pointed out later, better results can be expected with high residue creosote than with low or medium residue creosote. Practically all creosote used commercially is considered to be medium residue.

Fig. 3 illustrates the relationship between per cent serviceability and the 50 per cent point of the solvents. This point in the distillation curve was chosen because of its importance in current specifications (3) for solvents for pentachlorophenol. Fig. 3 shows that in general the higher the 50 per cent point, the higher the serviceability rating.

To summarize, the results on pressure treated test stakes show that the high distillation range pentachlorophenol solvents give the best performance in ground contact exposure. The indications are that 5 per cent pentachlorophenol in a solvent which has at least 50 per cent distilling above 500° F. can be expected to give good performance in ground contact exposure. It is also evident that a superior product can be obtained, preservation-wise, by using solvents of very high distillation characteristics. In contrast, the solvents which are very volatile are not as effective pentachlorophenol

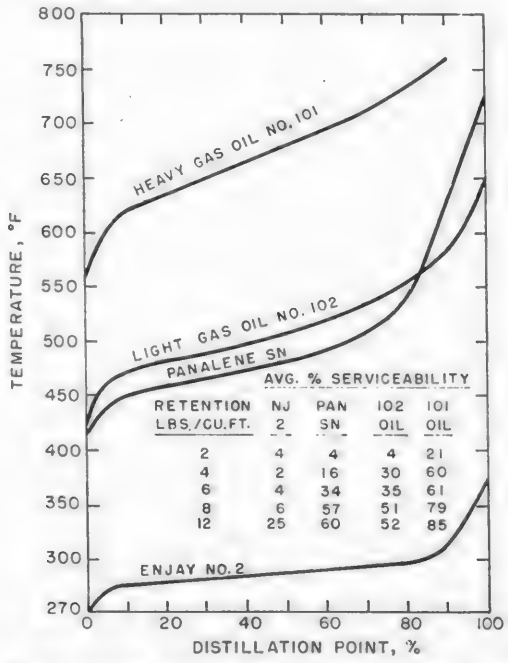

TEMPERATURE, °F
DISTILLATION POINT, %
HEAVY GAS OIL NO. 101
LIGHT GAS OIL NO. 102
PANALENE SN
ENJAY NO. 2
AVG. % SERVICEABILITY
RETENTION LBS./CU.FT. | NJ 2 | PAN SN | 102 OIL | 101 OIL
2 | 4 | 4 | 4 | 21
4 | 2 | 16 | 30 | 60
6 | 4 | 34 | 35 | 61
8 | 6 | 57 | 51 | 79
12 | 25 | 60 | 52 | 85

Fig. 2.—Relationship between per cent serviceability of 1949 stakes and distillation range of the pentachlorophenol solvents.

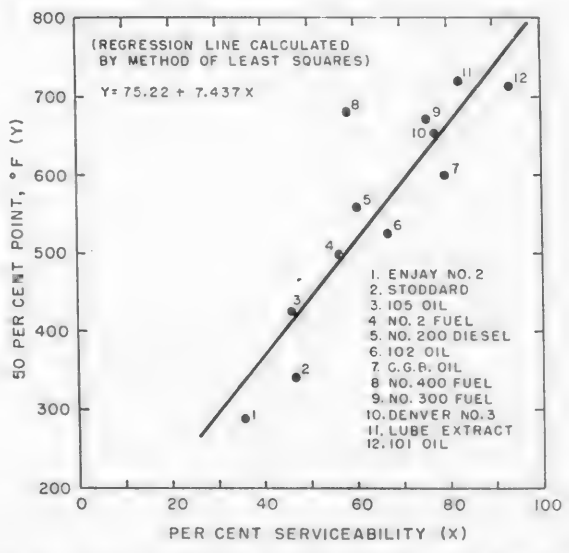

(REGRESSION LINE CALCULATED BY METHOD OF LEAST SQUARES)
Y= 75.22 + 7.437 X
50 PER CENT POINT, °F (Y)
PER CENT SERVICEABILITY (X)
1. ENJAY NO. 2
2. STODDARD
3. 105 OIL
4. NO. 2 FUEL
5. NO. 200 DIESEL
6. 102 OIL
7. C.G.B. OIL
8. NO. 400 FUEL
9. NO. 300 FUEL
10. DENVER NO. 3
11. LUBE EXTRACT
12. 101 OIL

Fig. 3.—Relationship between per cent serviceability of 1948 stakes and the 50 per cent distillation point of the oil carrier.

carriers for wood in ground contact as the higher boiling solvents.

Effect of Aromatic Content: The ¾- x ¾- x 18-inch stakes installed in 1949 give some information on how the aromatic content of the carrier effects the serviceability rating of the treated stake. Fig. 2 shows the distillation patterns of Panalene SN and Light Gas Oil No. 102 to be very similar and the serviceability ratings of the stakes treated with the various retentions of pentachlorophenol in the two oils to be in the same range. Panalene SN as shown in Appendix III is approximately 93 per cent aromatic whereas Light Gas Oil No. 102 is 41 per cent. Also, Heavy Gas Oil No. 101, which gives the best results in the same test, is only 56 per cent aromatic compared with 93 per cent for Panalene SN.

Table 2 shows that stakes treated with Panalene SN without pentachlorophenol are in better condition than those treated with Light Gas Oil No. 102 without pentachlorophenol, indicating that Panalene SN is somewhat active as a wood preservative, probably due to the high aromatic content. The presence of pentachlorophenol, however, appears to far outweigh any differences in the oils themselves as far as aromatic content is concerned.

On the basis of the limited data available from this experiment it is indicated that the aromatic content of the oil is not a significant factor in the performance of the oil as a carrier for pentachlorophenol.

Effect of Other Characteristics of the Carrier: Information on the gravity, viscosity, flash point and pentachlorophenol solvency is given in Appendix II for the oils used in the 1948 test. The serviceability ratings in general increase as the A.P.I. gravity decreases.

Viscosity is important in that it is related to permeability or ability to penetrate the wood. In these tests it was observed that No. 400 fuel oil failed to give complete penetration. In a few instances, No. 300 fuel oil also gave incomplete penetration. No correlation appears to exist between the viscosity of the oils and serviceability ratings obtained when adequate penetration was obtained.

Flash point again is related to distillation range and itself gives no significant information as far as preservative performance is concerned.

The pentachlorophenol solvency may be important if the solubility of pentachlorophenol in each fraction of each oil were known. The figures in Appendix I give the solubility of pentachlorophenol in the whole oil. There appears to be no correlation between the figures available on solubility and serviceability ratings.

More complete data are available on the oils used in the 1949 test (Appendix III). The effect of aromatic content has already been discussed. The sulfur content, per cent olefins, per cent saturates, and per cent carbonaceous residue also are given for Panalene SN, Light Gas Oil No. 102, and Heavy Gas Oil No. 101. An examination of this information reveals that any effect exerted by these factors is overshadowed by the effect of distillation range. Since only three oils are involved, no final conclusions can be drawn in regard to the effect of these characteristics.

What are the reasons for the differences in the behavior of pentachlorophenol in the presence of various oils in ground contact exposure? The analysis of test stakes one year after installation (Table 1) shows that pentachlorophenol was present in all the stakes, regardless of the oil used, in about the same amount. These results, from borings taken through the face of the 2 x 4 stake at the center above ground, prove that the pentachlorophenol was in the stake at the time of installation. It has been reported (4), however, that the ligher carriers cause some movement of pentachlorophenol to the surface as the solvent evaporates. The pentachlorophenol, according to this theory, sloughs off or is washed off easily by rain. It is very doubtful if this line of reasoning explains the relatively poor performance with the light carriers, particularly in view of the analysis of borings one year after installation.

A more reasonable explanation is the difference in the amounts of nonvolatiles or residues deposited in the wood by the various solvents.

Duncan and Richards (2) have tested the same group of oils listed in Table 1 by the soil block test procedure and have found that none possess any significant effectiveness themselves as preservatives although the rate of decay was slow. The field tests also show that those stakes containing the higher boiling oils, with no pentachlorophenol present, decay at a slower rate than untreated wood, the rate of decay generally being inversely proportional to the amount of high boiling or nonvolatile fractions present. In view of the fact that it has been shown (2) that these same oils are not fungistatic, the indication is that the non-volatiles act as a deterrent to decay, probably through their effect on moisture content or other physical effects.

Sedziak (5) reports that in soil decay laboratory tests, less decay was obtained with pentachlorophenol in No. 2 fuel oil than with pentachlorophenol in varsol, a more volatile solvent.

Creosote is similarly affected by the residue or non-volatiles present. This is pointed out in three recent publications. Colley (6) shows that in stake tests high residue creosote gives better service life than medium residue creosote which in turn is superior to low residue creosote. A report (7) in the American Railway Engineering Association Bulletin also describes superior performance by high residue creosote in contrast to low residue creosote. Mayfield (8) states that the service life of utility poles can be improved by increasing the distillation residue of the creosote.

Conclusions

On the basis of field experiments on pressure treated stakes, completed to date, the following conclusions are indicated.

1. The distillation range of oils used as pentachlorophenol carriers is an important factor in the performance of the treated wood in ground contact exposure. In general, the higher the distillation range of the solvent, the better the performance of the treated wood.

2. Characteristics of the carrier such as aromatic content, pentachlorophenol solvency, gravity, viscosity, and flash point do not appear to be significantly important.

Literature Cited

1. Blew, J. O. 1955. Comparison of wood preservatives in stake tests (1955 progress report). Forest Products Laboratory Report No. 1761.
2. Duncan, C. G. and Richards, C. A. 1950. Evaluating wood preservatives by soil-block tests: 1. Effect of the carrier on pentachlorophenol solutions. Proc. Amer. Wood Preserv. Assoc. 46:131.
3. American Wood Preservers Association Specification P-9-52.
4. Hudson, M. S. 1953. Recovery of solvent from wood pressure treated with oil-borne preservatives and its effect on paintability. Proc. Amer. Wood Preserv. Assoc. 49:146.
5. Sedziak, H. P. 1952. The evaluation of two modern wood preservatives. J. For. Prod. Res. Soc. II (5):260.
6. Colley, R. H. The evaluation of wood preservatives. Monograph 2118, Bell Tel. System Techn. Publ.
7. Amer. Ry. Eng. Assoc. Bull. Vol. 56, No. 519, December, 1954, page 491–5
8. Mayfield, P. B. Jan. 1955. How treating changes affect pole life. Elec. Light and Power.

Appendix

Appendix I.—CHARACTERISTICS OF CREOSOTE USED IN 1948 STAKE TESTS

	High Residue Creosote
Specific Gravity 38°C./15.5°	1.107
Benzol insoluble	.33%
Coke residue	1.46%
Moisture	3.4%
Distilling up to 210°C.	1.2
235°	3.6
270°	16.8
315°	35.2
355°	57.4
Residue above 355°C.	41.9
Distillation loss	.7
Total	100.0

Appendix III.—TYPICAL ANALYSIS OF OILS USED IN 1949 STAKE TEST

Properties	Enjay No. 2	Panalene SN	Light Gas Oil No. 102	Heavy Gas Oil No. 101
Distillation range, °F. (ASTM D-158)				
IBP	268	414	416	558
10%	282	449	469	619
20%	284	459	479	636
30%	284	466	487	653
40%	286	473	497	661
50%	288	481	508	680
60%	289	492	521	694
70%	291	510	536	709
80%	295	540	555	734
90%	311	624	581	760+
FBP	372	724	651	-----
API Gravity 60/60 F° (ASTM D-287)	34.3	11.9	28.0	7.5
Viscosity (ASTM D83)				
SUS at 100°F.		102.6	35.0	115.0
SUS at 210°F.		3.5	1.1	3.6
Aniline Point °C (ASTM D-611)	-----	Freezes	45.8	25.6
% Sulfur		0.11	1.43	3.14
% Aromatics (by H_2SO_4)		93	41	56
% Olefins (by H_2SO_4)		4	3	19
% Saturates (paraffinic)		3	56	22
% Carbonaceous residue	-----	3.01	0.13	1.01
Flash Point, °F., PMCC (ASTM D-93)	80	220	210	310
Pentachlorophenol solubility at 100° F.	5+	37.1	32.6	28.3

Appendix II.—CHARACTERISTICS OF OILS USED IN 1948 STAKE TEST

Petroleum Oils	Gravity API/60	Flash Point	Pentachlorophenol Solvency (% by Weight) 75°F.	ASTM Distillation, °F. IBP	10%	20%	30%	40%	50%	60%	70%	80%	90%	End	% Rec.	Viscosity S.U.S. 100°F.	130°F.
Enjay Solvent No. 2	34.3	80°F.	5+	268	282	284	284	286	288	289	291	295	311	372	98	-----	-----
Stoddard Solvent	48.2	103	5+	313	326	329	333	336	342	345	352	360	374	419	98	-----	-----
No. 2 Fuel Oil	37.4	176	5+	352	421	446	464	482	498	516	536	558	594	651	98	33.0	-----
Heavy Thermal Side Cut No. 105	38.8	148	10–12	365	388	397	408	414	426	437	451	469	500	563	98	31.4	31.0
No. 200 Diesel Oil	30.5	180	8–10	415	486	513	532	547	559	581	606	628	666	727	97	40.9	36.4
Catalytic Gas Base Oil	23.2	172	14–16	494	540	554	572	586	601	617	633	653	680	707	97	43.4	38.3
No. 300 Fuel Oil	14.8	196	12–14	410	520	599	637	667	673	675	678	---	---	680	78	640.8	247.6
No. 400 Fuel Oil	12.9	184	16–18	423	567	637	658	669	680	687	684	---	---	694	74	2431.0	871.2
Light Gas Oil No. 102	30.0	220	10–12	459	482	491	504	514	525	538	554	579	612	693	97	37.6	34.2
Denver No. 3 Oil Blend	22.6	166	10–12	428	487	514	550	608	655	671	682	689	---	689	86	99.2	71.8
Heavy Gas Oil No. 101	8.3	345	20–22	608	660	676	689	700	716	729	736	759	---	763	98	167.4	91.3
Lube Oil Extract No. 465E	5.1	295	28–30	482	588	637	671	694	711	725	747	---	---	757	82	196.4	97.1

Improved Utilization of Western Hardwoods by Modern Drying[1]

HARVEY H. SMITH

Forest Utilization Service, California Forest and Range Experiment Station[2]
Forest Service, U. S. Department of Agriculture

Increasing amounts of western hardwoods are being cut commercially and more species will be used as economical conditions become favorable and suitable uses are found for them. Application of modern drying practices and manufacture of high-quality lumber will contribute to their fuller utilization.

SATISFACTORY DRYING of western hardwoods is a tremendously important consideration in their fuller utilization. While some uses may be developed that do not require drying of sawed lumber, such as wood pulp and veneer, extensive use of hardwoods in the future will require that drying techniques be developed. Some western hardwoods are difficult to dry but have characteristics that make them valuable woods for many purposes, providing they can be processed properly.

Volume and Quality of Western Hardwoods

First, what are the species and quantities of western hardwoods? Forest schools have taught the dendrology of 300 or more eastern and southern hardwoods, but seldom considered the hardwoods in the West of any commercial value. However, interest is now increasing in utilization of several western species that grow in significant volumes.

The full extent of western hardwoods has not been accurately known until recently because they were not included in timber surveys. Figures from different sources often varied considerably. Past estimates agreed in only one particular: hardwood stands in the West were not comparable to those in the East and South.

Recent, more comprehensive surveys show a more optimistic picture of western stands. Several factors have resulted in this improved outlook: improved survey methods, measuring to a smaller diameter at breast height, measuring to a smaller top diameter, including species formerly not measured, and including areas formerly classed as inaccessible.

Sawtimber stands for the more important western hardwoods are estimated to total 23 billion board-feet in the three Pacific Coast states (Table 1). These figures include only sawtimber growing on commercial timber lands. Some species, like red alder and black cottonwood, grow mostly along stream bottoms in noncommercial tim-

[1] Presented at Session II, Wood Drying, FPRS Ninth National Meeting, June 21–24, 1955, in Seattle, Wash.

[2] Maintained at Berkeley, Calif., in cooperation with the University of California.

The Author: Harvey H. Smith attended U. of Illinois and U. of Michigan, holds B.F. and M.F. degrees. He worked with U. S. Forest Service from 1935–38 and private industry in the Northeast from 1938–42. Smith conducted seasoning research at U. S. Forest Products Lab from 1942–48, when he transferred to California Region.

Table 1.—ESTIMATED VOLUME OF HARDWOOD SAWTIMBER, BY SPECIES, IN CALIFORNIA, OREGON AND WASHINGTON

Species	California	Oregon	Washington	Total
		Millions of Board Feet		
Red alder	150	3,900	5,100	9,150
Black cottonwood	-----	-----	1,000	1,000
Pacific madrone	800	800	-----	1,600
Bigleaf maple	-----	1,500	1,800	3,300
California black oak	1,900	500	-----	2,400
Tanoak	2,000	1,700	-----	3,700
Other species	1,150	600	100	1,850
Total	6,000	9,000	8,000	23,000

ber areas. Trees growing on these smaller, highly productive sites are often of excellent quality and are usually accessible. The timber on these lands will add a good deal to the hardwood volume.

There may be some question about the quality of western hardwoods. It is true that most of the volume in "other species" for California is live oak of very low grade, quite unsuitable for sawing into lumber. Fortunately, this is not the case with several other western hardwoods. Cooperative studies of log and lumber grades conducted by the Oregon Forest Products Laboratory and the U. S. Forest Products Laboratory show that the yields of No. 1 common and better lumber of red alder and bigleaf maple are comparable to those for eastern hardwood species (1, 2).[3] Also, tanoak trees of good size and form are found as a true timber-type throughout the redwood region.

Whenever the quality of western hardwoods is discussed, it is well to think of the size and quality of logs now manufactured into lumber and other sawed items in other parts of the country. In one study of southern pine, for instance, "small" logs averaged 6.5 inches d.b.h. and produced 16 bd. ft. per log. The "large" logs averaged 10.9 inches d.b.h. and sawed out less than 70 bd. ft. per log. When sawing small logs, the mill cut was 8,509 bd. ft. in one 8-hour shift.

Perhaps it is grossly unfair to compare western hardwoods to southern softwoods, because conditions other than log size are no doubt also vastly different. However, these figures provide a better basis for judging western hardwoods than the size and form of western softwoods, which is the usual standard in the timber industry.

All in all, the volume and quality of western hardwoods encourage the belief that they can be the basis for a substantial hardwood industry. A good start has already been made with two species, red alder and bigleaf maple, which are reaching the market in appreciable volumes. Several factors have favored use of alder and maple. They occur in relatively large timber stands. The trees are of good size and form, qualities which make for good yield and grade recovery. And the lumber is relatively easy to dry. Three other species, Oregon ash, black cottonwood, and California laurel, are also utilized to some extent. It is significant that four of these five species closely resemble one or more eastern hardwoods and are finding similar uses in industry. Only the laurel has no real counterpart among the eastern hardwoods. It is used extensively as a specialty wood in the novelty trade, seldom as lumber.

Two other species may also develop in commercial importance—tanoak and California black oak. Neither, however, matches alder and maple in all of these essential factors: volume, form, and ease of seasoning.

Tanoak sawtimber equals bigleaf maple in total volume and its volume per acre is fairly high in some areas. The form of the trees in these areas is often very good also, but tanoak must be classed as a difficult wood to dry, particularly in sizes thicker than 1 inch. With respect to checking, it is similar to white oak and beech, both of which are relatively difficult to dry.

California black oak, which ranks fourth in volume among western hardwoods, is found in more scattered stands than tanoak, and the form of the trees, with few exceptions, is not as good. Seasoning studies at the California Forest and Range Experiment Station have shown that black oak does dry easily, as oaks go, especially in the thinner sizes, and drying should not be a limiting factor in its full utilization (3, 4). Nevertheless, several attempts to produce black oak lumber commercially have failed. The reasons for these failures were associated with quality of manufacture and the drying procedure used. There is good reason to believe that a serious effort to utilize this species will succeed if proper equipment and technical know-how are used.

It is apparent that the key to fuller utilization of western hardwoods is a better understanding and application of several basic parts of both the air-drying and kiln-drying processes.

Some hardwoods can be dried to the desired low final moisture content by kiln-drying green from the saw, whereas others respond best to a combination of air-drying followed by kiln-drying. Red alder, black cottonwood, Oregon ash, bigleaf maple, and California laurel can be kiln-dried green from the saw. But for these woods, too, well controlled air-drying before kiln-drying will reduce drying degrade and under most conditions reduce total drying costs. Tanoak, California black oak, and Oregon white oak respond best to the combination of air-drying followed by kiln-drying.

Air-drying: Of the many aspects of air-drying, two concepts are exceedingly important in seasoning hardwoods. One is warp control by adequate piling, and second is proper yard layout and pile spacing to speed drying.

Adequate piling is important in air-drying western hardwoods to prevent excessive warping, which is a problem because of the great shrinkage potential of these woods. The strength values of native American woods (5, 6) show the high shrinkage values for western hardwoods. Also, the sharp curvature of the growth rings in flat-sawed lumber from small logs results in serious cupping during drying. The normal tendencies of these woods to shrink and warp during drying can be controlled best by careful piling on adequate pile foundations with a sufficient number of crosses or stickers. In kiln-drying, the drying schedule used may contribute to warp control, but in air-drying adequate piling is the one important factor.

Accurate sawing to a uniform thickness will make good piling possible. It is virtually impossible to do a good job of piling miscut, thick and thin lumber. Another advantage of accurately sawed lumber is that it will dry more uniformly. Drying time is a function of the square of the drying thickness; therefore, even slight differences in thickness are reflected in great differences in final moisture content after air-drying or kiln-drying.

Pile spacing and pile orientation are effective in controlling the rate of drying. Air-drying studies recently completed by the California Redwood Association (7) with piles spaced from 4 to 8 feet apart showed a progressively greater drying rate with greater pile spacing. The drying rate in a completely isolated, free-standing pile was the greatest observed in this study.

Orientation of the lumber piles is often predetermined by the shape of the yard and the location of existing buildings. At other sites there is more latitude of choice. If the yard layout

[3] Numbers in parentheses refer to literature cited.

permits adequate alleys and cross alleys and good pile spacing, orientation with respect to the sun appears to be much more important than orientation with respect to prevailing winds. A north-south orientation allows the sun to reach the ground between the piles at least part of each day at all seasons of the year. Thus more heat gets to the yard and the lumber. Relatively less sun reaches only the tops of lumber piles—where there is already too much heat. Adequate alleys, cross alleys, and pile spacing will promote good air circulation regardless of the direction of the prevailing winds.

The following suggestions for piling will keep warping at a minimum and promote rapid air-drying:

(1) Pile the lumber for drying, using 9 or more stickers per course (for 16-foot lumber) with accurate vertical alignment of the stickers.

(2) Move the lumber promptly from saw to the lumber pile and protect it from the sun enroute. (Unprotected lumber will check in only a few hours of exposure to the sun.)

(3) Provide high pile foundations (18-inch to 24-inch minimum) that are open to horizontal air movement in all directions.

(4) Pile foundations should support the pile under each vertical row of stickers for hand piling and at 5 or more positions for unit package piling.

(5) Provide good pile roofs to keep rain out of the piles and to protect the top courses of lumber from direct sun.

(6) Maintain wide spacing between piles of unit packages (1 to 6 feet, depending on the species and the climatic conditions) to permit the sun to reach the ground between the piles and the air to circulate through the yard.

(7) Orient the piles north and south to allow the sun to reach between the piles.

Kiln-drying: Recommended kiln schedules have been published for the six western hardwood species now finding their way into the lumber trade. Investigations by laboratories and schools have resulted in suggested schedules for seasoning other western hardwoods.

The Oregon Forest Products Laboratory and the U. S. Forest Products Laboratory have published schedules (8, 9, 10). The Oregon Forest Products Laboratory has made a special effort to solve some of the obstacles that presently hinder the fuller utilization of western hardwoods, and deserves congratulations on the accomplishments to date. Much of the material presented here is based on results of the Oregon work.

In applying published schedules to the drying of western hardwoods, the following considerations are especially important:

Taking kiln samples—Modern kiln-drying schedules are based on the moisture content of the wood during the drying cycle. Kiln samples (11) provide the best record of the moisture content during drying. Their use is therefore recommended, particularly when kiln drying hardwood lumber green from the saw.

Kiln-drying previously air-dried lumber—Kiln-drying thoroughly air-dried lumber is relatively easy. The moisture content is well below the fiber saturation point, hence the danger of degrade is greatly reduced. Furthermore, the stress pattern in the lumber is established, and the accuracy of kiln-drying conditions is less critical. For these reasons the recommended schedules for thoroughly air-dried lumber often consist of only one or two steps, calling for rather high temperatures and low humidities.

For lumber that is not thoroughly dry, only moderate temperatures are recommended until a moisture content of 15 to 20 per cent is reached, when high final temperatures can be used to speed drying. The humidities used are the same as for stock that has been kiln-dried green from the saw and has reached a comparable moisture content.

Lumber moved from the yard to the kiln during rainy, slow-drying weather, however, may surface check if immediately subjected to low humidities in the kiln before a new, steeper moisture gradient is established. For this reason the suggested starting humidity for such yard lumber is higher than for stock that has been kiln-dried green from the saw and has reached a comparable moisture content. The high humidity is maintained one day or less, depending on the moisture content at the surface of the lumber. After the new moisture gradient is established, low humidities can be used without danger.

Equalizing and conditioning—Equalizing and conditioning are important in kiln-drying western hardwoods. An effective equalizing treatment will assure a uniform final moisture content. When a kiln charge of lumber has reached an average final moisture content which is at or even below that desired, there is usually a considerable difference between the surface and center moisture content, and between the average moisture content of different boards. These differences are equalized by using a higher humidity than was used in the final stages of the drying cycle. This will prevent the dryer pieces from drying further, and at the same time allow the wetter pieces to continue drying. Since most bigleaf maple and red alder lumber is used in the manufacture of furniture, where a low, uniform moisture content is required, equalizing these two woods is certainly desirable.

Conditioning relieves the residual drying stresses that develop as a normal function of drying both on the yard and in the kiln. This process is related to but distinctly different from equalizing. Serious drying stresses may be present even though the moisture gradient within the piece is extremely flat. The surface fibers in such lumber are in compression while the center fibers are in tension (12). A final steaming or high humidity treatment causes the surface fibers to pick up moisture. The compression forces in the surface fibers are thus increased, and when the fibers are stressed beyond the elastic limit they take on a new, smaller dimension. The excess surface moisture is quickly dissipated as the lumber cools when pulled from the kiln, and the drying stresses are relieved.

Recent experiments at the University of Michigan have shown that high temperatures are also very important in the conditioning treatment (13). Kiln operators have always used high temperatures during conditioning because of the plasticizing effect, but this study indicates that the temperature effect is more important than was suspected.

Coloring red alder lumber—The color of red alder lumber is an important consideration, as well as its moisture content and stress. Many furniture manufacturers prefer red alder lumber having a uniform light-brown color. Commercial kiln operators have found that the color of red alder can be varied from nearly white to a chocolate brown, depending upon the initial temperatures and humidities used in kiln-drying the stock green from the saw. In a recent study at the Oregon Forest Products Laboratory (14), an optimum steaming treatment for coloring red alder was found to be 140° F. dry bulb temperature with a 4° wet bulb depression for 18 to 24 hours. This steaming treatment was effective in coloring alder lumber that was to be air-dried prior to final kiln-drying. No sticker stain developed either during air-drying or subsequent kiln-drying.

Conclusion

Western hardwoods constitute a large natural resource, larger than formerly supposed. Industry is already using some species. Wider use will require good seasoning. This usually means thorough air-drying and careful kiln-drying. By applying the best of modern drying practices and manufacturing high quality lumber, the industry can realize greater returns from western hardwood timber.

Literature Cited

1. Wollin, A. C. and Pfeiffer, J. R. 1955. Oregon maple log and lumber grading. Oregon Forest Products Lab. Report No. G–4.
2. Pfeiffer, J. R. and Wollin, A. C. 1954. Red alder log and lumber grading. Oregon Forest Products Lab. Report No. G–3.
3. Smith, H. H. 1949. Seasoning California black oak. U. S. Forest Service. Calif. Forest and Range Expt. Sta. Res. Note No. 62.
4. Smith, H. H. 1950. Further experiments in seasoning California black oak. U. S. Forest Service. Calif. Forest and Range Expt. Sta. Res. Note No. 75.
5. Markwardt, L. J. 1930. Comparative strength properties of woods grown in the United States. U. S. Dept. Agr. Tech. Bul. 158.
6. Pfeiffer, J. R. 1953. Data for Oregon hardwoods. Oregon Forest Products Lab. Report No. G–2.
7. Anon. 1953. California Redwood Assoc. Research Project Interim Reports A through F, Index No. 3.21411.
8. Torgeson, O. W. 1951. Schedules for the kiln drying of wood. U. S. Forest Service. Forest Product Lab. Report No. D1791.
9. Espenas, L. D. 1953. The seasoning of 1-inch tanoak lumber. Oregon Forest Products Lab.
10. Espenas, L. D. 1951. The seasoning of Oregon hardwoods. Oregon Forest Products Lab. Information Circ. No. 6.
11. Anon. 1954. Use of kiln samples in operating a lumber dry kiln. U. S. Forest Service. Forest Products Lab. Report No. 1607.
12. McMillen, J. M. 1955. Drying stresses in red oak. Forest Products Jour. V (1): 71–76.
13. Churchill, J. M. and Dickinson, F. E. 1954. The effect of time, temperature, and relative humidity on the relief of casehardening stresses. U. of Mich.
14. Anderson, B. G. and Frashour, R. G. 1955. Sticker stain in 1-inch red alder lumber. Oregon Forest Products La

Casehardening Stress Relief of Ponderosa Pine[1]

LYLE D. WINKEL

Research Engineer, Western Pine Association, Portland, Oregon

Study was undertaken to determine efficient means of conditioning ponderosa pine to relieve casehardening stresses. Comparative tests revealed that conditioning time could be reduced from 24 hours to 4 hours by cooling lumber prior to conditioning, by injecting water into the steam spray line, and by increasing the quantity of steam. Three water injection devices tested are illustrated.

Introduction

THE SPRAYING OF LUMBER with generous amounts of steam to relieve the casehardening stresses developed during kiln drying has been generally practiced for many years. Stress removal by conditioning is an important step in producing quality stock for resawing or ripping. Recommendations without basic study of the effect of temperature, relative humidity, and length of time have been made to promote effective conditioning. Various techniques and equipment have been devised by trial and error methods. Therefore, a study was needed to test recommendations and obtain data for the design and operation of devices and equipment.

Several variable factors such as the rate of drying, texture of stock, moisture content, and kiln construction affect the intensity of stresses and the relief of them. A study of these variables is not included in this report.

The factor of greatest influence is steam for the use of conditioning. Steam will vary from mill to mill in pressure, quality, and quantity. A low pressure steamsystem supplies steam of saturated qualities which will provide high relative humidity and equilibrium moisture conditions at high temperatures. A high pressure steam system supplying steam at higher pressures is dry in quality which will provide high temperatures, but low humidities. In W.P.A. Research Note No. 4.5222 it is pointed out:

> "While it is easy to heat the lumber by the use of steam jets, merely turning on high pressure steam for a few hours frequently fails to get desired results in the way of stress relief. The reason is that high pressure steam expanded to atmospheric pressure seldom yields kiln humidities higher than 70% and at 170° kiln temperature the surface fibers would not rise above 9% moisture content. While saturated steam is used at most mills, boiler pressure steam is no longer saturated when its pressure is dropped to that of the atmosphere without work being done, but rather is highly superheated. If only super-heated steam is available, the super-heat at atmospheric pressure is correspondingly greater. Means must be found then to absorb this super-heat so that the humidity may be high enough to cause a rather large surface pick up in moisture content."

A recommended practice for conditioning is to close all the vents, close all heating coils, and open the spray line for a maximum steam flow. This technique will rarely produce relatively high humidities. Therefore, what means could be used to obtain the high relative humidities? The means were directed toward the size of the spray line and orifice openings for steam quality and pressure reduction, the possible cooling of lumber prior to the final conditioning, and the mixing of cold or hot water with the steam to reduce pressure and superheating. Some or all of these ideas may be useful in absorbing the superheat to produce saturated conditions.

The purpose of this study, therefore, was to determine the degree of effect which these various methods had upon the efficiency of conditioning to relieve casehardening stresses. Because the results of the tests demonstrated in Fig. 1 were based upon resawing

[1] Presented at Session II, Wood Drying, FPRS Ninth National Meeting, June 21–24, 1955, in Seattle, Wash.

The Author: Lyle D. Winkel, a graduate of Oregon State College, was employed at Medford Corp., Medford, Ore., for 3½ years before joining seasoning staff of Western Pine Assoc. in Feb. 1953. A World War II veteran, Winkel completed two years of pre-forestry at Mission House College, Plymouth, Wis., before entering service.

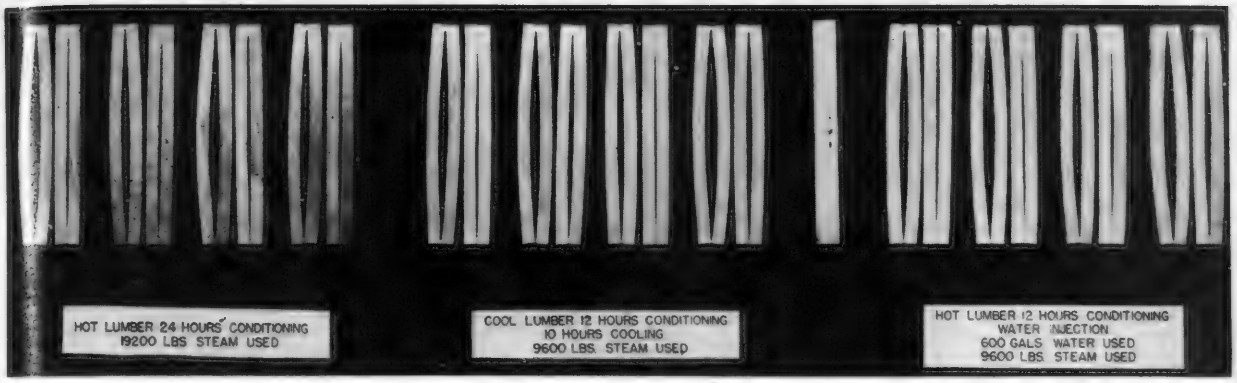

HOT LUMBER 24 HOURS CONDITIONING
19200 LBS STEAM USED
COOL LUMBER 12 HOURS CONDITIONING
10 HOURS COOLING
9600 LBS STEAM USED
HOT LUMBER 12 HOURS CONDITIONING
WATER INJECTION
600 GALS WATER USED
9600 LBS STEAM USED

Fig. 1.—Stress samples before and after conditioning.

stock into two pieces, they do not apply for softwoods or hardwoods when more than one resaw cut is made.

Casehardening stresses and their development have been explained in many research bulletins and textbooks (1,2,3,4,5).[2]

Test Procedure

A test program was planned which simulated equipment, material, methods, and sampling techniques used in kiln drying of softwood species.

Equipment

The Western Pine Association test kiln at the Brooks-Scanlon Lumber Co., Bend, Ore., was used for this study. The kiln is of standard cross sections, but only one crib long, approximately, 16-feet wide x 22-feet high x 25-feet long inside dimensions. The load rests on a scale for continuous weighing during a test period.

A spray line with thermocouple wells and pressure gauges was installed to record temperature and pressure of the steam. Steam flow was recorded with a steam flow meter or computed at controlled pressures for three sizes of orifice openings into the kiln air. Steam flow through an orifice to the atmosphere was computed by Napiers Formula:

$$W = \frac{Pa}{70}$$

W = Steam flow in lbs/sec.
P = Pressure in pounds per square inch absolute.
a = Orifice size in sq. in.

Thermocouples were placed inside the kiln for data of dry bulb, wet bulb and lumber surface temperature. The scale recorded the increase in weight due to moisture absorption during each test run. The following devices were installed in the spray line for injection of water into the steam spray line before entering into the kiln: (1) Venturi, (2) Tee siphon, and (3) Desuperheater (See Fig. 2).

[2] Numbers in parentheses refer to literature cited.

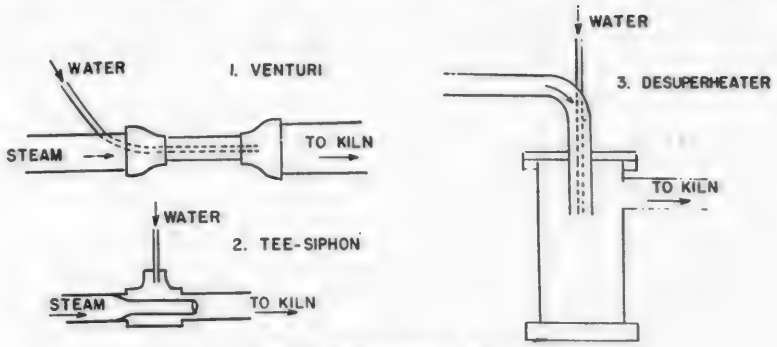


Fig. 2.—Water injection devices.

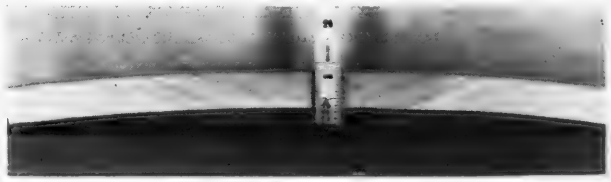


Fig. 3.—Cup measurement.

Other devices were tried but the steam flow was limited because of orifice sizes. Therefore testing was centered around the 3 listed devices. Water flow, pressure and temperature were recorded with instruments in the water supply line.

Material

Test material was 6/4 Shop, ponderosa pine, 16 feet long in quantities of 10,000 bd. ft. The stock was dried in the mills cross-circulation kilns to a moisture content of 6–10%. The schedule used for drying the test material was one which controlled the rate of drying for desired speed and resulting quality in the region.

Sampling

The test crib was pulled from a kiln charge and 10 boards, 6/4-inch x 12-inch x 16-foot were selected for stress sampling. One stress sample was cut from each of four selected boards located along the outside edge of the crib before the test and marked control stress samples. These were surfaced to standard sizes, and allowed to equalize moisture content. Six more boards were selected for stress sampling after the test to determine the average per cent of stress relief. All selected boards were pulled from the planer chain after the test, stress samples were cut and allowed to equalize shell and core moisture content. All control and test stress samples were resawn into two pieces, each piece designated as pith or bark side. They were laid on a flat surface, the cupped face down and measured to an accuracy of .01 inch at the greatest curvature (Fig. 3.

The measurements of the pith and bark sides were added for the total amount of cup and divided by two for the average cup. The per cent of stress relief was computed from these measurements of the average amount of cup for each piece. Calculations were as follows:

$$\text{Control Sample} \frac{.40}{2} = .20\text{-inch avg. cup}$$

$$\text{Treated Sample} \frac{.16}{2} = .08\text{-inch avg. cup}$$

$$\text{Stress Relief} = \frac{.20-.08}{.20} \times 100 = 60\%$$

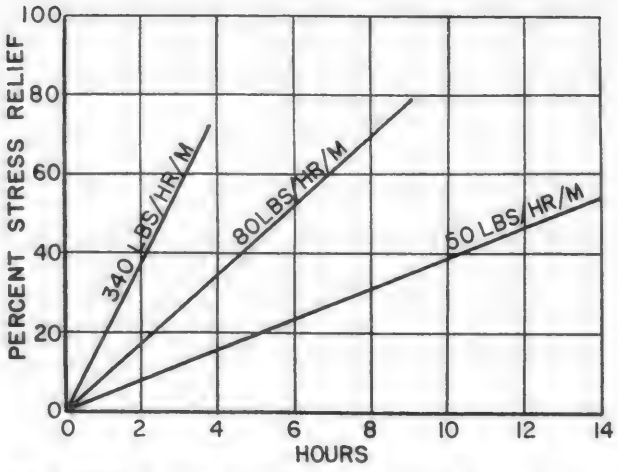


Fig. 4.—Effect of steam quantity upon stress relief in relation to time.

Table 1.—EFFECT OF CONDITIONING METHODS, TIME, AND TOTAL STEAM USED UPON STRESS RELIEF

Test No.	Total Hours	Hours Cooling	Lbs. Steam per hr/M	Total Steam Used Lbs/M	Per cent Actual Stress Relief
1. Hot Lumber	24	-	80	1920	83.5
2. Cool Lumber	9	5	80	720	76.5
3. Water Injection	12	-	70	840	78.0
4. Hot Lumber	4	-	340	1360	32.9
5. Cool Lumber	4	2	340	1360	75.6
6. Water Injection	4	-	340	1360	57.5

Test Method

The following practice was maintained throughout all tests. All heating coils were closed, all vents were closed, and the spray line was opened full. The only control was on steam pressure to maintain a desired flow. Therefore, maximum humidity and E.M.C. was reached as governed by the condition of the steam at the given pressure and the quantity which the orifice openings would exhaust to the atmosphere. Many tests were made with various sizes of orifice openings in the spray line at several controlled pressures to the orifices. Only those tests which confirmed the best results for shortest time are reported here.

The following factors and methods were tested to determine their effect upon the relief of stresses in relation to time: (1) steam volume, (2) lumber temperature, (3) water injection, and (4) air circulation.

Results

Steam volumes: An increase in steam volume directly influenced the rate and final relief of stresses.

An indication of the effect of increased steam quantities on stress relief and time is shown by Fig. 4 for three tests of cooled lumber. The conditioning time was reduced and the stress relief was equal or better at increased steam quantities. Although this fact is true, the use of steam over 100 lbs/hr/M appears to be impractical for efficient conditioning.

For example, a demand of more than 100 lbs. of steam per hour per thousand board feet would require more than 5,000 lbs. of steam per hour for a kiln capacity of 50,000 bd. ft. of ponderosa pine. To install boiler capacity beyond this requirement would not be efficient to supply steam only for conditioning. Even at a maximum rate of 100 lbs./hr/M it would require 145 Bhp.

$$\text{Bhp} = \frac{100 \text{ lbs/hr/M} \times \frac{50\text{M}}{\text{M}}}{34.5 \text{ lbs/hr/Bhp}} = 145 \text{ Bhp.}$$

From various sources it is reported that a range of 3600 to 5000 lbs. of steam per M bd. ft. would be required to dry the kiln charge cited and that a maximum demand at initial hours will be as much as 175 Bhp (6,7). Within a battery of kilns, a demand of 145 Bhp can be supplied for a short time of conditioning when other charges are demanding less steam for drying. On the basis of this analysis, it would be inefficient to require more than 100 lbs of steam/hr/M bd.ft. of lumber for conditioning. Additional analyses are made with steam consumption in regard to stress relief later in this paper.

Conditioning Methods: Figs. 5, 6, and 7 demonstrate the results of three conditioning methods; hot lumber, cool lumber and water injection at the indicated steam and water quantities. The graphs demonstrate the effect of the conditioning method on temperatures and gain in weight in relation to time.

The methods of cooling lumber and injecting water reduced the superheating effect of the steam to provide more moisture for absorption. This is indicated by the comparative rate of gain in weight and higher relative humidity. The total weight gain was less, yet more effective because of the increased rate of weight gain during the time of increasing wet bulb temperatures. The rate of moisture absorption seems to be more effective than the maximum temperatures attained.

Table 1 shows the per cent of stress relief for Test Nos. 1, 2, and 3 in relation to the time and quantity of steam used. Considerable savings of

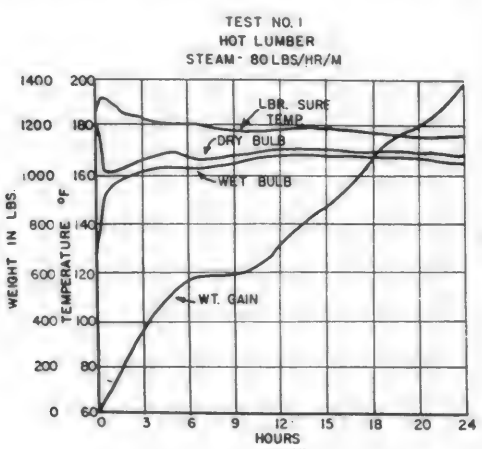


Fig. 5

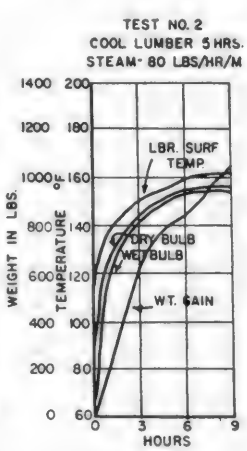


Fig. 6

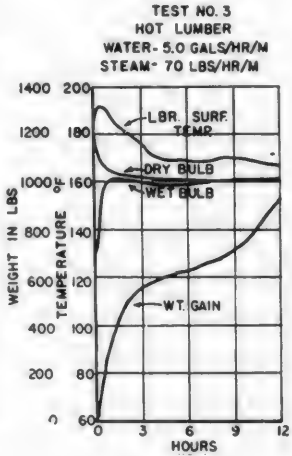


Fig. 7

Effect of conditioning methods on temperature and weight gain in relation to time.

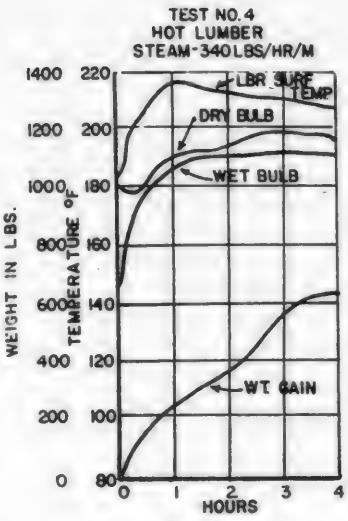


Fig. 8

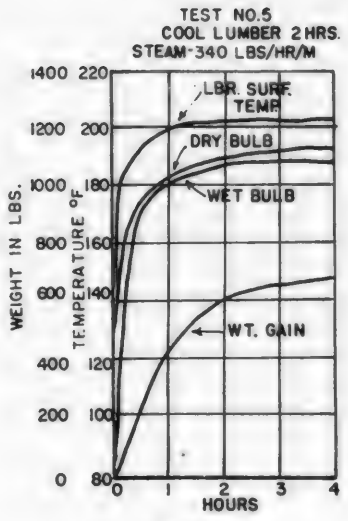


Fig. 9

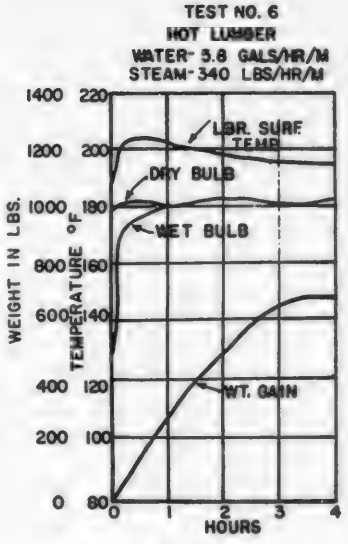


Fig. 10

Effect of conditioning methods on temperature and weight gain in relation to time.

steam were realized by cooling the lumber, or injecting water into the steam spray with desuperheating devices. The results show that for shorter periods of time, cool lumber and water injection methods produced as well a stress relief as hot lumber tests of 24 hours. Cooling time added 5 hours to the actual conditioning time for a total of 14 hours to effect the same stress relief; a water injection method effected the same stress relief in 12 hours.

Larger quantities of steam were used in other studies to determine a maximum limit of steam use in relation to time and stress relief. This resulted in higher temperatures, more rapid moisture absorption, and a faster rate of stress relief. Figs. 8, 9, and 10 demonstrate the results of three conditioning methods: hot lumber, cool lumber, and water injection at a steam quantity of 340 lbs/hr/M.

Cooling of lumber and injection of water reduced the superheating effect of the steam. This provided more moisture for absorption as the wet bulb temperature increased. This is indicated by the increased rate of weight gain due to higher relative humidities at higher temperatures. Table 1 shows the per cent of stress relief obtained as affected by the conditioning methods (Tests 4, 5, 6), time and total steam used. The results show that for equal periods of time and larger steam quantities, the per cent of stress relief is improved by cooling the lumber or injecting water into the steam.

The use of 340 lbs/hr/M does not produce a proportional ¼ reduction in time for better stress relief as compared to the use of 80 lbs./hr/M. Using steam above a sensible steam generation (previously analyzed) without realization of shorter time for faster better stress relief is not logical. Therefore, for economical limits of steam use in relation to stress relief, a maximum of 80–100 lbs/hr/M is more reasonable.

Note that in all the graphs of each test, the lumber surface temperature curve is higher than the dry bulb temperature. This is due to the generation of heat of absorption when water vapor is absorbed by dry wood. The release of this heat consists of the heat of wetting and heat of vaporization when water vapor is involved as in steam conditioning (8).

Cold vs. Hot Water Injection: The use of hot water simulated a system to collect and inject condensate from other kilns into the steam spray line or the use of a separate heating process for this purpose. The results show that water at 65° F. effected a stress relief of 48%, whereas water at 177° F. effected a stress relief of only 56%. All other variables were the same for this comparative test. The extra equipment to supply hot water would be unnecessary for such a small improvement in stress relief.

Effect of Air Circulation: Variation of the uniformity in stress relief across the width of test loads 9 feet wide was notable due to air circulation direction. The trends affected by one-way circulation, no circulation, and reverse circulation are demonstrated by Fig. 11.

One-way circulation revealed a high-to-low stress relief from the entering to the leaving side of the load (left to right). This indication was general with most tests using one-way circulation.

No circulation produced a high-low-high per cent of stress relief across the width of test loads. Although this simulates the use of a steam chamber for conditioning, the trend is not serious enough for adequate uniformity of stress relief. In the kiln these results suggest that the fans could be shut off to save power during conditioning.

Reversing circulation produced a much more uniform stress relief across the width of a load. Air circulation should be reversed during the conditioning time. Therefore, stress relief can be improved in uniformity across the load just as much as uniformity of drying is achieved by reversed circulation.

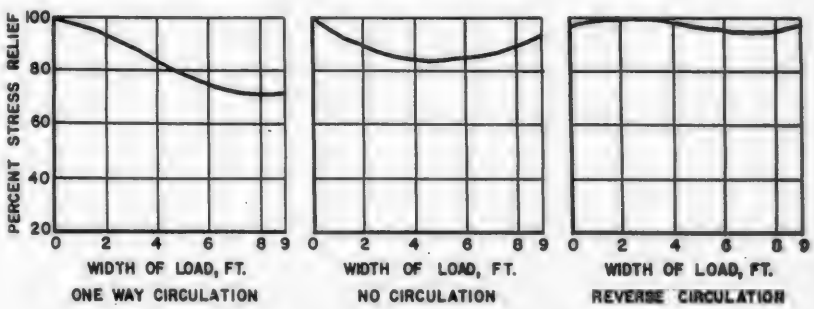


Fig. 11.—Effect of air circulation on uniformity of stress relief.

Recommendations

1. Steam volume, pressure, and the resulting temperature are primary factors for efficient relief of drying stresses. The free flow of steam with a minimum of back pressure must be provided by orifice openings which will exhaust the maximum steam flow for the installed spray line pipe. The total area of the orifice openings should be slightly greater than the internal area of the spray pipe. The steam flow of 80 to 100 lbs of steam/-hr/M bd ft at a pressure of 30 psig near the outlet is an economical quantity of steam use for efficient relief of casehardening stresses. Where more steam is available, conditioning time will be shorter, but at a rate of over 100 lbs/hr/M the use of greater quantities become less economical.

2. Since all tests were based upon continuous spraying, the best results can be obtained in this manner. Control of tempreatures for specific humidities and equilibrium moisture content is not required on the basis of the test procedures and results. The temperatures of 160° to 180° should be practical to attain by continuous steam flow at 80 to 100 lbs of steam/-hr/M.

3. Cooling of lumber reduces the conditioning time to approximately one-half of the time necessary for hot lumber. Cooling inside the kiln to a temperature of approximately 115° or complete cooling outside for more than 5 hours will provide uniformly low lumber temperatures for uniform stress relief, save conditioning time and steam. Cooling appears to have no adverse affect upon grade. Fig. 1 and tests illustrated show that cooling of lumber can be beneficial to reduce conditioning time.

4. Mixing of water with high pressure superheated steam will reduce conditioning time by one-half the time needed for conditioning of hot lumber. Devices installed in the spray line system for water injection eliminate cooling time, effectively raise the humidity, and save steam. Fig. 1 illustrates the quality of stress relief with the use of water injection devices.

The use of approximately 2 to 5 gallons of water per hour per M bd. ft. mixed with the 80 to 100 lbs. of steam/hr./M would be sufficient water to produce saturated conditions and prevent excessive wetting. Redrying time is unnecessary because the release of heat evaporates all of the moisture absorbed during conditioning.

All three types of water injection devices used in the tests are satisfactory as illustrated by the graphs presented and other data too lengthy to include in this report. Most important are pressure differences between water and steam. The venturi device operates well at pressure differences of approximately 40 psig if the narrowed portion is one-half the diameter of the upstream and downstream pipe diameter, or if the downstream pipe diameter is half again as large as the upstream pipe diameter. The same are required for the tee-siphon. The desuperheater device must exhaust the mixed steam and water into a spray line pipe twice the diameter of the supply line. If the initial water and steam pressures are the same, the design corrections are unnecessary, except that these corrections induce pressure reduction. Hot water is slightly more effective than cold water. Extra equipment to supply condensate or to heat water would be of small advantage.

Reversing of air circulation during conditioning is required for uniform stress relief.

Acknowledgments

Acknowledgment is extended to the management and employees of the Brooks–Scanlon Lbr. Co., Bend, Ore., for their cooperation in making this study possible; to Mr. Graham of the Bumstead–Woolford Co., Portland, Ore.; to Harvey Oster, Lovsted Kiln Co., Seattle, Wash.; and to Hans Slagsvold, Brooks–Scanlon Lbr. Co., Bend, Ore.

Literature Cited

1. Herman, Albert. 1952. Casehardening of lumber. Western Pine Assoc. Research Note No. 4.5222.
2. Tieman, H. D. 1944. Wood technology 14: 186–203.
3. Baker, W. J. 1950. Drying stresses in lumber seasoning. U. S. Forest Products Laboratory, No. R 1652.
4. Brown, H. P., Panshin, A. J., and Forsaith, C. C. 1952. Textbook of wood technology, Vol. II. 52–4.
5. Koehler and Thelen. 1926. Kiln drying of lumber. 4: 45–70.
6. Teesdale, L. V. 1950. Steam requirements in lumber dry kilns. U. S. Forest Products Laboratory No. R 1478.
7. White, H. E., J. Neils Lumber Co. 1943; Wishard, C. A., Moore Dry Kiln Co. 1953. Steam consumption in western pine dry kilns. Form No. 791, June 17. 1953.
8. Brown, H. P., Panshin, A. J., and Forsaith, C. C. 1952. Textbook of wood technology. Vol. II. 92–6.

Discussion

J. D. Snodgrass (Oregon State College): How was the effectiveness of stress relief measured?

Mr. Winkel: Control samples and test samples of standard finished dimensions were resawn and measured. Each half was then placed on a flat surface and deviation due to cupping through the center of the piece from the flat surface was measured to the nearest .01 inch. Each of the two halves for the respective samples was measured independently and the two measurements were then averaged. The per cent of relief was based on control samples from like boards.

Mr. Snodgrass: Why were the weight gain curves of a signoid shape?

Mr. Winkel: For unknown reasons after temperatures reached highest levels, a fall-off of weight gain resulted; possibly a maximum of moisture was absorbed at the conditions reached and equilibrium could not be maintained.

Carl Rasmussen (Western Pine Assoc.): Since this research was done on softwoods, it is not recommended for hardwoods.

R. C. Rietz (U. S. Forest Products Lab): I would define this practice as a steaming treatment in contrast to conditioning treatment for stress relief in hardwoods. Mr. Rasmussen stated, however, that some thought had been given to this point and they had decided that this was definitely a conditioning treatment. Mr. Winkel concluded that this treatment is aimed at material that will be resawn.

Strength Properties of Plantation-Grown Slash Pine[1]

PAUL R. KRAMER and ROBERT L. SMITH

Head, Forest Products Department, Texas Forest Service, Lufkin, Texas; and Supervisor, Statistical Laboratory, Texas Agricultural Experiment Station, College Station, Texas

Extensive plantations of slash pine in East Texas and Southwest Louisiana are now attaining merchantable size. Since these plantings represent extensions of the natural range of this species, questions have been raised concerning their physical and mechanical properties. This paper reports results of standard strength tests and evaluates use of I.B.M. techniques in analyzing strength test data.

Introduction

MANAGEMENT METHODS for southern yellow pine plantations in the South are an important part of our forestry practice. The magnitude of the future contribution of artifically regenerated stands to the wood resource is a matter of daily increasing evidence. Great strides have been made in the establishment and care of planted areas. Silvicultural problems, particularly those having economic implications, remain to be solved.

Meantime, the aggregate area and individual size of existing plantations has confronted us with the corollary problem of utilization practices and economics. Utilization is the economic objective of forest management. One of the prime factors dictating utilization standards is wood quality.

This report is designed to provide some of the requisite preliminary answers to questions concerning the properties of wood obtained from young, slash pine plantations.

Origin of Problem

Slash pine (*Pinus elliottii* var. *elliottii*) has a natural range that is generally confined to the lower coastal plain area east of the Mississippi River to South Carolina. In this area the species possesses a favorable growth capacity. Thousands of acres of slash pine plantations have been established within the last three decades. Many of these extend beyond the species natural range and as far west as the limits of natural growth southern yellow pine in Texas.

The increasing average age of existing plantations, the extent of plantation establishment, and the pressure of steadily ascending stumpage values have resulted in probing questions by industry. Will plantation-grown slash pine trees produce wood equivalent in physical and mechanical properties to that yielded by trees of forest-grown origin? The question has also been raised concerning the probable future quality of material from these plantings in consideration of the fact that the species was planted beyond its natural range.

Some of these planted areas already contain trees of merchantable size for sawlogs. Many will soon reach this stage. Merchantability is a consequence of tree growth and also of our diminishing size concept of a sawlog *per se*. Moreover, utilization requirements for products other than sawlogs are involved.

Strength Properties of Plantation-Grown Trees: Little information concerning the strength properties of plantation-grown wood is available. No strength property data for plantation-grown southern yellow pines have been located in published literature. This lack of information is understandable considering the need of these data. Olson et al[2] have reported on the properties of several native and introduced species grown in plantations in the Northeast. A number of publications covering foreign investigations of the same general problem are not pertinent.

The published record of strength test results on plantation-grown stock of coniferous species other than slash pine indicate several general conclusions. The first and foremost is that such stock does not usually measure up to the strength standards attained by material from mature, forest grown trees. It is generally conceded that the origin of the stand is probably not an important contributing factor. It would appear that physiological age, character of growth, anatomical structure, and the non-uniformity of the material available for testing are rather complexly involved in the reduced strength character.

It should be pointed out, however, that plantation-grown *Pinus radiata* in Australia[3] was found to have mechanical properties roughly comparable to mature trees of other species from forest origin.

Definition of Project

A study of the strength properties of plantation-grown slash pine in East Texas and Southwest Louisiana was initiated to furnish provisional information concerning the following objectives:

(a) Quantitatively define the strength property status of young, merchantable-sized, plantation trees.

(b) Substantiate from a utilization viewpoint, the desirability of growing slash pine beyond its natural range.

(c) Determine if site or geographical location are important factors in the development of strength properties.

(d) Measure the relative influence of certain physical properties upon strength.

(e) Provide an experimental basis for the periodic retesting of the changing stature of strength properties with increasing tree age.

It is immediately recognizable that these objects allude to an experimental frame of reference and do not strictly describe a finite project. However, this approach is aimed at satisfying some of the immediate needs, and also pro-

[1] Presented at Session VI, Chemical Utilization, Ninth National Meeting, FPRS, June 21-24, 1955, in Seattle, Wash.

The Authors: Paul R. Kramer received B.S. from Washington State College, did graduate work at Yale U. He is a past chairman of FPRS Mid-South Section and National Advisory Committee.

R. L. Smith received B.S. in electrical engineering from Texas A. & M. College, has 10 years experience in scientific computing. He is the author of several papers on adaptation of punched card techniques to various phases of scientific computing.

[2] Olson, A. R., Poletika, N. V., and Hicock, H. W. 1947. Strength properties of plantation-grown coniferous woods. Conn. Agri. Exp. Sta. Bull. 511.

[3] Langlands, Ian. 1938. The mechanical properties of South Australian plantation-grown *Pinus radiata* D. Don. Commonwealth of Australia. Council for Scientific and Industrial Research Pamphlet No. 87.

Fig. 1.—Outline map of East Texas showing general limit of commercial southern yellow pine and location of slash pine plantations used in study.

viding for the sustained consideration of the problem.

Location of Source Material

Six sample plantation areas were selected for source material for this study. They comprise some of the oldest known slash pine plantations in the general area under consideration. The areas individually represent tree ages from 18 to 28 years. The six locations furnished two sites in the Gulf-Coast Flatwoods area (Nos. 3 and 4) and four sites in the Middle Coastal-Plain area.

Fig. 1 shows the general location of the sample plantations by name and reference number. This map also provides information regarding the western limit of naturally occurring southern yellow pine.

Unfortunately, slash pine plantations of acceptable age and size were not available on a strictly comparable basis. Neither the site qualities, dates of planting, survival percentages, nor the type and kind of stand treatment are consistently comparable. However, the size of trees selected for cutting was kept as similar as possible.

Description of Plantations

A brief description of the various plantations used as sources for trees tested is given in Table 1. All of these plantations were established on a 6- x 8-foot spacing. The seed sources are imperfectly known.

Table 1.—SUMMARY OF TREES AND PLANTATIONS FURNISHING STRENGTH PROPERTY TEST MATERIAL

Locations	Tree Data*			Stand Data			Site Data	
	Age	Mean Diam.	Total Height	Stocking	Cutting History	Fire History	Site Quality	Soil Character
1. Boykin	18	11.5	42	Poor	None	Burn	Fair	Shallow Sandy Loam
2. Douglassville	22	12.0	45	Good	Thinned	None	Good	Sandy Loam
3. Kirbyville	28	11.2	54	Fair	Thinned	None	Very Good	Deep Sandy Loam
4. Elizabeth, La.	27	12.4	55	Excellent	None	None	Very Good	Deep Sandy Loam
5. Maydelle	20	11.6	49	Good	Thinned	None	Good	Clay Loam
6. Ratcliff	18	10.4	42	Good	None	None	Fair	Shallow Sandy Loam
All	21	11.5	48					

*Based on 10 trees per location.

The Boykin area represents one of the poorer sites of the several locations. The surface soil is quite thin and the planting was established on a hilltop. Survival was spotty and indiscriminate burning has resulted in further losses in stocking. The original planting was a mixture of slash and loblolly pines. No management operations have taken place on this area.

The Douglassville area is a planting on "worn-out" cotton land. While the site would appear to be poor, the height and diameter growth of the plantation belie this conclusion. Upon inspection, the soil was found to be a deep sandy loam. Tree survival is very good and the area was thinned one year before the test bolts were obtained.

The Kirbyville location is on a State Forest and complete records are available for this plantation. This is an excellent site (site index 100–110) on a deep soil of high fertility and with excellent moisture relationships. The area has never suffered from fire and is acknowledged the oldest slash pine planting in Texas. The area was thinned two and eight years respectively previous to the collection of the test bolts. At that time some of the co-dominants were removed.

The Elizabeth, Louisiana, location was included in the study because of its similarity in site and age classification with the Kirbyville planting. Both of these lie in the "flatwoods" area. The planting has never been thinned, survival is excellent, and fires have been excluded.

The Maydelle area was planted in 1934 and later inter-planted because of poor survival. The test bolts were obtained from trees in the original planting. The soil is of good depth and contains an appreciable clay fraction. The stand has been thinned. Light, controlled fires have been permitted to run through the stand.

The Ratcliff plantation represents a comparatively inferior site but with good survival and current stocking. Fire has been excluded. No thinning or harvesting operation have been applied to the stand. Dominance is drastically expressed by individual trees in this planting. There are indications of slow growth during the early years.

Selection of Test Material

A sample of ten trees per area was selected to furnish bolts for the test sticks. Since the larger diameters were desired, this led to cutting only dominant or strongly co-dominant stems. These trees were cut into four-foot bolts in accordance with ASTM Specifications. The bolts were then sawed into 2½-inch test squares, matched, and separated into portions for drying and testing. One-half the sticks were

tested green and the other half piled for air-drying. The air-dried sticks were tested after reaching a moisture content of approximately 14 per cent.

Since it was necessary to saw out the pith and, whenever possible, the first year's annual growth, the production of test sticks was practically limited to four sticks per bolt. Wood for test purpose was limited to clear material. The net result of this culling operation, as is shown later, is that all of the original sample of ten trees per location are not represented in the final test sample.

Figs. 2 and 3 are illustrations of the top end of typical four-foot test bolts from which the strength test material was obtained. These bolts clearly illustrate some of the variation in number of rings per inch and per cent summerwood present in the test material.

Testing Procedure

Testing of strength properties was initiated on the green specimens immediately after sawing of the sample sticks. Only clear samples of wood were used and ASTM procedures[4] followed throughout. No tests were made for impact bending, toughness, or nail withdrawal.

The following list indicates the specific tests employed and the strength property determinations made for each test.

1. Static Bending
   a. Stress at Proportional Limit
   b. Modulus of Rupture
   c. Modulus of Elasticity
   d. Work to Proportional Limit
2. Compression Parallel to Grain
   a. Stress at Proportional Limit
   b. Maximum Crushing Strength
3. Compression Perpendicular to Grain
   a. Stress at Proportional Limit
4. Hardness
   a. End
   b. Side
5. Shear Parallel to Grain
   a. Maximum Shearing Strength
6. Cleavage
   a. Load to Cause Splitting
7. Tension Perpendicular to Grain
   a. Maximum Tensile Strength

The maximum number of static bending samples available from the material from any one location was used as the basis for determining the number of tests to be made. The number of static bending samples varied from a low of 6 to a high of 21. The number of samples in the remaining tests were based on percentages of the number available for static bending tes

[4] American Society for Testing Materials. Standard Methods of Testing Small Clear Specimens of Timber. ASTM D 143–52.

Fig. 2.—Top of first 16-foot log from tree at Boykin location. Note rapid growth and small proportion of summerwood.

Fig. 3.—Top of first 16-foot log from tree at Kirbyville location. Note steady deceleration of growth rate and relatively high proportion of summerwood.

The number of rings per inch, per cent summerwood, and moisture content were determined for each test specimen.

Specific gravity was tested on a locational basis only with ten determinations per location. These data were referenced to bolt and test piece number so that strength values could be recovered. Shrinkage samples were obtained in the same fashion except that no effort was made to retain bolt or piece identity. Samples for radial shrinkage only were obtained. The size and growth character of the material being tested did not allow the practical testing of tangential shrinkage.

The tests were run on an Olson 60,000-pound, Universal Testing machine which had been recently cali-

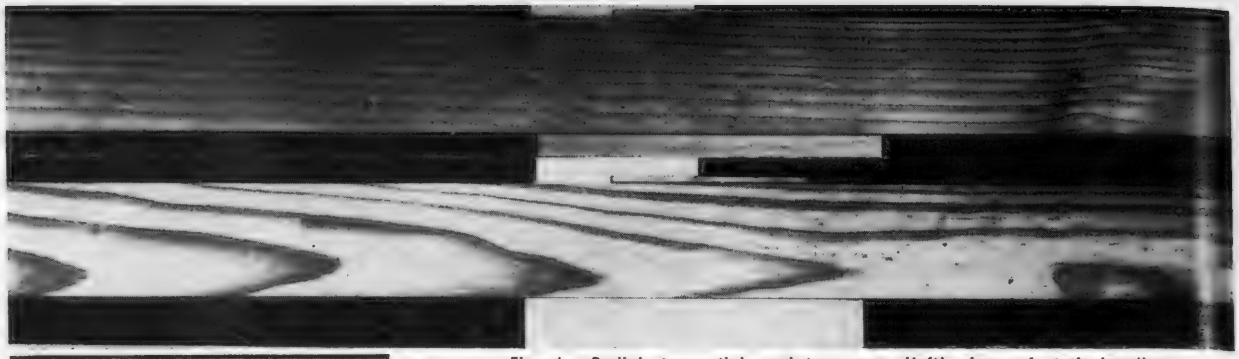


Fig. 4.—Radial, tangential, and transverse (left) views of static bending sample from Elizabeth, La. location.

brated and attested. The order of tests performed was according to the order listed. No test specimens were obtained from wood used in previous tests. Obvious compression wood was excluded.

Figs. 4 and 5 are illustrations of typical test specimens for the static bending test.

Results of Tests

Table 2 lists the number of tests performed by moisture content condition for each location and for each strength property. When related to Tables 3 and 4, it will allow statistical comparisons with known data.

The actual test results, summarized as means, are set forth in Table 3. These values were obtained from testing the respective number of samples given in Table 2.

Table 4 is presented to call attention to the problem of variability. It comprises the standard deviations of the test means given in the summary table.

These three tables consitute the entire test results. The casual reader will probably be impressed with the relatively large amount of variation exhibited by individual properties. This is a natural phenomenon of the material being tested. Some discussion of this matter is presented in the latter portion of this paper.

Discussion of Results

Probably one of the more puzzling features of these tests is the inability of the air-dried test sticks to provide strength values appreciably in excess of those obtained from green samples. This is particularly evident in the static bending tests.

Another feature of interest is the rather low mean strength values obtained from the test material. While general indications of this result might be drawn from work done with other species, the gross size of the disparity is striking. A reasonable explanation for this lack of strength is probably not justified at this time because of the intricacies involved. It is presumed that physiological age is introduced as a factor.

Normally it would be expected that the hardness values for the end test to exceed those for the side test. If we include both green and dry tests, nearly one-half the results proved opposite to expectations. However, since the mean values for combined locations were normally ordered, we might consider sampling size as a factor in this uncommon inversion.

In a number of instances the failures of test specimens were adjudged to be of a brash character. Careful selection and culling of the test material both before and after the tests eliminated recognizable compression wood as a factor. In this case it is believed that a relatively low latewood component and rapid growth promoted the failures having brash characteristics.

While not startling in their magnitude, it is rather apparent that there are locational differences in the test

Table 2.—SUMMARY OF TREES, SAMPLES, AND NUMBER OF TESTS PERFORMED

Location of Samples	Moisture Content Condition	Trees Tested	Number of Samples					Number of Tests Performed					
			Rings per inch	% Summerwood	% Moisture	Specific Gravity	Shrinkage	Static Bending	Compression Parallel to Grain	Compression Perpendicular to Grain	Hardness	Shear Parallel to Grain	Cleavage	Tension Perpendicular to Grain
Boykin	Green	8	42	42	42	10	10	6	10	4	4	6	6	
	Dry	6	70	70	70	10	10	11	11	6	6	12	12	1
Douglassville	Green	8	71	71	71	10	10	11	12	6	6	12	12	1
	Dry	8	70	70	70	10	10	10	12	6	6	12	12	1
Kirbyville	Green	8	79	79	79	10	10	18	8	8	9	12	12	1
	Dry	7	95	95	95	10	10	21	17	10	11	12	12	1
Elizabeth, La.	Green	7	71	71	71	10	10	14	11	5	5	12	12	1
	Dry	6	64	64	64	10	10	10	7	6	5	12	12	1
Maydelle	Green	8	63	63	63	10	10	8	11	4	4	12	12	1
	Dry	7	70	70	70	10	10	12	12	6	6	10	12	1
Ratcliff	Green	9	47	47	47	10	10	7	6	5	5	8	8	
	Dry	8	68	68	68	10	10	11	9	6	6	12	12	1
All Locations	Green	48	373	373	373	60	60	64	58	32	33	62	62	6
	Dry	42	437	437	437	60	60	75	68	40	40	70	72	7

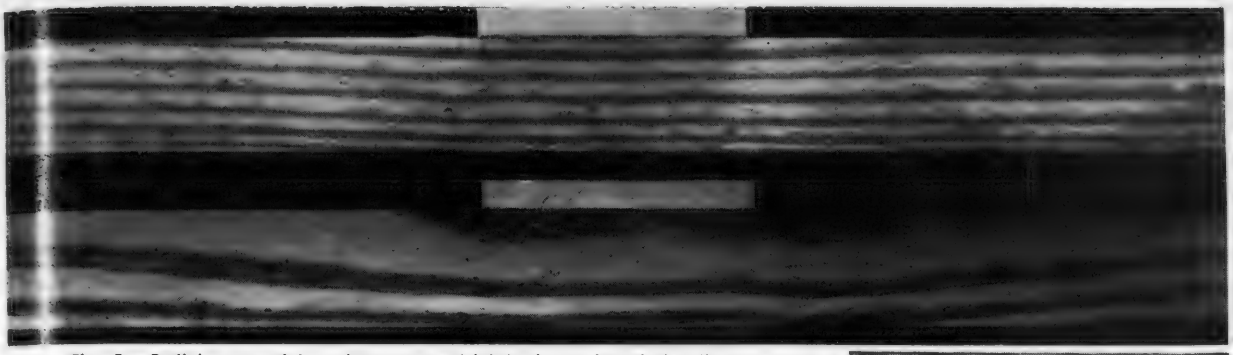


Fig. 5.—Radial, tangential, and transverse (right) views of static bending sample from Douglassville location.

results. This matter is examined in more detail later.

Statistical Measurements

A careful review of the preliminary summaries of the test results indicated that only a portion of the data was suitable for statistical analysis. This was due to a number of factors, the more important of which have to do with the size of the total sample of material available and also with the impracticality of obtaining specific gravity values for all strength property tests.

However, enough of the data are available for examination to provide a basis for tentative conclusions on a number of points of interest.

An indication of the variability of the data can be obtained from the means (Table 3) and the standard deviations (Table 4).

While not shown as a part of this report, an analysis of variance illustrated the desirability of extensive sampling as a requisite to the establishment of species means for strength properties. This analysis also indicated that there are significant differences in the strength properties of wood obtained from the different locations. This is particularly true for modulus of rupture and maximum crushing strength. Locations 3 and 4 were markedly superior sites on the basis of their original examination and selection. The

Table 3.—SUMMARY OF PROPERTIES OF PLANTATION-GROWN SLASH PINE

(Mean Values)

(1)	(2)	(3)	(4)	(5)	(6)		(7)	(8)	(9)	(10)	(11)	(12)
		All Tests							Static Bending			
					Specific Gravity							
Source of Material	Location Number	Rings per in. (Number)	Per cent Summerwood	Per cent Moisture	Volume at Test	Volume O. D.	Per cent Shrinkage (Radial)	Moisture Content Condition	SPL p.s.i.	R p.s.i.	E 1000 p.s.i.	WPL in.-lb. per cu. in.
Boykin	1	2.9	31	163	.40	----	4.4	Green	2900	4700	620	0.78
		2.7	25	14	.47	.50	--	Dry	3600	6300	820	0.89
Douglassville	2	2.9	31	139	.43	----	4.2	Green	2900	5400	740	0.68
		2.9	33	14	.51	.54		Dry	3200	7200	810	0.69
Kirbyville	3	3.5	36	129	.44	----	4.2	Green	3500	6800	1240	0.57
		3.8	35	14	.49	.54	----	Dry	4300	9300	1370	0.78
Elizabeth, La.	4	3.4	32	144	.41	----	5.5	Green	3500	5900	930	0.74
		3.5	34	14	.49	.53	----	Dry	4000	8500	1130	0.81
Maydelle	5	2.4	27	106	.41	----	3.8	Green	3000	4900	660	0.76
		2.5	25	14	.43	.46	--	Dry	3900	8100	940	0.92
Rateliff	6	3.0	26	141	.43	----	2.7	Green	3000	5200	770	0.67
		3.0	26	14	.46	.49	----	Dry	4000	8200	1140	0.81
All Locations	--	3.1	31	133	.42	--	4.2	Green	3200	5800	900	0.68
		3.1	30	14	.48	.51	----	Dry	3900	8100	1080	0.81

(1)	(2)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
		Compression ∥ to Grain		Compression ⊥ to Grain	Hardness		Shear ∥ to Grain	Cleavage	Tension ⊥ to Grain
Source of Material	Location Number	SPL p.s.i.	MCR p.s.i.	SPL p.s.i.	End lbs.	Side lbs.	p.s.i.	lbs./in. width	p.s.i.
Boykin	1	3000	3900	410	400	410	740	150	290
		4100	7100	730	530	490	1400	210	230
Douglassville	2	2500	4100	430	330	370	850	160	320
		2700	6300	740	660	630	1680	210	250
Kirbyville	3	3400	5300	400	410	440	820	170	320
		6700	10,200	860	650	620	1790	250	270
Elizabeth, La.	4	3500	4800	360	450	470	910	170	370
		5700	8500	820	610	570	1590	240	280
Maydelle	5	3200	4200	400	450	450	690	180	330
		4100	7700	710	640	520	1250	220	230
Rateliff	6	2500	4100	370	370	410	850	170	300
		4200	7500	680	500	470	1260	250	230
All Locations		3000	4400	400	400	430	820	170	320
		4600	8000	770	620	550	1500	230	250

Table 4.—SUMMARY OF STANDARD DEVIATIONS OF MEANS

(1)	(2)	(3)	(4)	(5)	(6)		(7)	(8)	(9)	(10)	(11)	(12)
		All Tests							Static Bending			
					Specific Gravity				SPL	R	E	WPL
Source of Material	Location Number	Rings per in. (Number)	Per cent Summerwood	Per cent Moisture	Volume at Test	Volume O. D.	Per cent Shrinkage (Radial)	Moisture Content Condition	p.s.i.	p.s.i.	1000 p.s.i.	in.-lb. per cu. in.
Boykin	1	.56	5.3	25.7	.03	----	1.00	Green	360	650	230	.14
		.56	5.9	.74	.03	.03	----	Dry	740	1000	260	.24
Douglassville	2	.89	6.1	14.9	.03	----	.90	Green	420	550	200	.13
		.65	5.8	1.34	.04	.04	----	Dry	410	800	240	.10
Kirbyville	3	.85	9.2	16.9	.06	----	.82	Green	430	800	280	.11
		.85	5.6	1.00	.04	.05	----	Dry	540	1040	220	.16
Elizabeth, La.	4	.75	6.3	29.4	.04	----	1.90	Green	460	600	190	.12
		.66	6.3	.85	.05	.06	----	Dry	480	940	170	.18
Maydelle	5	.62	9.0	36.7	.03	----	.76	Green	510	810	210	.15
		.56	5.9	.85	.03	.04	----	Dry	510	700	140	.13
Ratcliff	6	.78	5.5	20.6	.05	----	.39	Green	410	670	150	.09
		.69	7.1	.74	.06	.07	----	Dry	500	1120	270	.18
All Locations		.85	8.0	31.3	.04	----	1.21	Green	510	1010	310	.14
		.83	7.3	.97	.05	.05	----	Dry	650	1170	310	.17

(1)	(2)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
		Compression ∥ to Grain		Compression ⊥ to Grain	Hardness		Shear to Grain	Cleavage	Tension ⊥ to Grain
Source of Material	Location Number	SPL p.s.i.	MCR p.s.i.	SPL p.s.i.	End lbs.	Side lbs.	p.s.i.	lbs./in. width	p.s.i.
Boykin	1	890	840	130	80	110	55	23	60
		1060	880	80	105	75	480	38	100
Douglassville	2	530	500	35	40	35	65	23	45
		560	570	130	85	145	610	24	90
Kirbyville	3	910	870	40	65	120	130	28	60
		1600	1300	170	110	145	870	38	185
Elizabeth, La.	4	850	420	40	55	70	110	38	75
		560	910	150	80	155	580	49	215
Maydelle	5	510	460	30	90	35	95	39	45
		1030	930	105	205	140	190	31	135
Ratcliff	6	610	720	35	45	30	60	27	50
		1760	1820	160	120	140	180	56	165
All Locations		800	780	55	70	80	120	31	60
		1810	1760	150	125	145	570	42	155

test data indicate that these two locations are part of the same population with respect to strength properties. There were no valid a priori reasons for a separation of the remaining group of locations.

No effort is being made to selectively identify those factors contributing toward locational differences of strength properties. There is considerable credence to the suggestion of seed source as a possible factor.

We can conclude from these data that individual test specimens or averages from a small number of samples would probably furnish very imperfect information regarding strength properties if a geographic location or species average were desired.

Table 5.—SIMPLE AND MULTIPLE CORRELATION COEFFICIENTS FOR STRENGTH PROPERTIES* (Y) AND CERTAIN VARIABLES (X)

Variables		Green Test			Dry Test		
		Modulus Rupture Y_1	Max. Crush Y_2	Max. Shear Y_3	Modulus Rupture Y_1	Max. Crush. Y_2	Max. Shear Y_3
Rings per Inch	X_1	.565**	—.112	.392*	.339*	.307	.663**
Per cent Summerwood	X_2	.105	.395*	.414*	.404**	.493**	.422**
Moisture Content	X_3	—.356*	—.510**	—.017	.285	—.040	—.289
All R.y 123		.623**	.594**	.529**	.535**	.538**	.779**

*Within location.

Table 6.—PARTITIONING R^2*

(Air Dry Samples)

Test		Variables		Direct	Joint	Total
Modulus of Rupture	Y_1	Rings per inch	X_1	.071	.019	.090
		Per cent Summerwood	X_2	.123	.019	.142
		Moisture Content	X_3	.036	.018	.054
Maximum Shear	Y_2	Rings per inch	X_1	.449	—.005	.444
		Per cent Summerwood	X_2	.013	.035	.048
		Moisture Content	X_3	.149	—.037	.112
Maximum Crush	Y_3	Rings per inch	X_1	.032	.023	.055
		Per cent Summerwood	X_2	.215	.014	.229
		Moisture Content	X_3	.025	—.018	.006

*Within location.

Correlation Analysis

The variables of rings per inch, per cent summerwood, and moisture content within location, were correlated with certain of the strength properties. The results are shown in Table 5. All of the multiple correlation coefficients (R) were found to be highly significant. This would lead us to believe that the variables are associated with the indicated strength properties. But, in most cases, about as satisfactory prediction of strength property can be obtained from a single independent variable. This tendency is shown by the relative size of the simple correlation coefficients (r). However, the significance of any one pair of variables is not consistent. From a practical standpoint the simple correlation coefficient may be preferred.

If the variables were ranked according to their quality as predictive criteria of strength properties on the basis of these tests, we would place per cent summerwood first. This would be followed by number of rings per inch and moisture content respectively. Of course, the case for moisture content should be viewed in the light of the fact that in the green test it should not be considered a variable of any influence and in the dry test its variation

is of such small magnitude as to minimize its use as a correlating factor.

Table 6 represents a partitioning of the square of the multiple correlation coefficient (R^2) in order to direct attention to the relative contribution of the independent variables. The tabular figures for "direct" are obtained by squaring the respective standard net regression coefficients, while the "total" values are obtained as the product of the standard net regression coefficient and its corresponding simple correlation coefficient. The tabular values for "joint" are obtained by difference.

These data generally support the inference that the independent variables are important only as individual factors in their association with the strength values and not as a result of their influence in association with the remaining variables.

In summation, the correlation analysis for these data indicate that only a minor amount of importance can be consistently attached to number of rings per inch, per cent summerwood, and moisture content as variables influencing the stature of modulus of rupture, maximum crushing strength, and maximum shearing strength. It is probable that tree age is an unmeasurable factor of importance in these correlations. Tests made at a later age may substantiate or nullify this suggestion.

Implication of Variables

Specific gravity samples were not obtained for each tested specimen. However, samples were obtained for each location and related to test piece number. The results of the correlation analysis for modulus of rupture (Y_1), maximum crushing strength (Y_2), and maximum shearing strength (Y_3), are shown in Table 7.

The indicated correlation coefficients lend credence to the proposition of relating specific gravity with strength properties. The limited amount of data and the method of collection precludes any particular reliance on the property in this case. The high coefficients apparently result from the operation of a set of common causes of environmental character.

The specific gravity data were also analyzed in terms of their correlation with number of rings per inch (growth rate) and per cent summerwood. In neither case was the correlation coefficient of significant magnitude. Other commonly considered variables relating to strength properties are growth rate, percentage summerwood, and moisture content.

The plantation-grown stock was found to have growth rates which were of rapid character. These rapid growth rates undoubtedly engendered the formation of wood of sub-standard strength properties. Moreover, the growth character is apparently operating in such fashion as to reduce the feasibility of using rate of growth as a strength property variable. Its effect on strength properties was inconsistent.

Table 7.—CORRELATION OF SPECIFIC GRAVITY (X) WITH CERTAIN STRENGTH PROPERTIES (Y)*

Specific Gravity	Modulus of Rupture	Maximum Crushing Strength	Maximum Shearing Strength
X	Y_1	Y_2	Y_3
r	.722**	.734**	.918**

*Coefficients are for between location correlations.

The percentage of summerwood present was found to be subject to slightly less variation than that exhibited by number of rings per inch. However, according to these tests, the disparity between plantation-grown wood and normal wood with respect to per cent summerwood is less marked than was the case in number of rings per inch. The proportion of summerwood in the test pieces of this study was found to usually be of importance in the determination of strength properties.

Moisture content in the dry samples did not appear to be closely associated with the strength properties although this relationship could be masked by other factors.

Other variables of possible significance are those relating to position of the bolt or test stick in the tree, anatomical factors such as fibril angle, and the relation of grain alignment with the test specimen, physiological factors like maturation of cells and tissues, and the many imponderables and interactions of site with the above factors.

Because of the fairly limited number of test sticks obtained from certain bolts, no effort has been made to describe the effect of height position in the tree on strength properties. In columns 16, 17, 18, 19, and 20 (hardness, shear, cleavage, and tension), no significant differences could be determined between the radial and tangential aspects.

Comparison of Test Results

It is apparent that plantation-grown slash pine at the age of the test material does not have nearly equivalent strength properties. The exact reason for this inequality is not readily identified.

A comparison of the test results with published values for this species is given in Table 8. Of the strength properties, only compression parallel to grain could be adjudged as reaching equivalency.

The analysis of data obtained from this experiment does not support the obvious conclusion that the strength differences are primarily related to disproportionality of either growth rate or percentage summerwood. While specific gravity is recognized as a variable of prime importance, it would appear that all of the variables customarily used to assess strength quality in mature wood do not prove of similar diagnostic value in the case of this plantation-grown material. Such a conclu-

Table 8.—COMPARISON OF PROPERTIES OF PLANTATION-GROWN SLASH PINE WITH TREES OF FOREST GROWN ORIGIN

Property	Natural Slash Pine*		Plantation Slash Pine		Ratio Plantation/Natural	
	Green	Dry	Green	Dry	Green	Dry
Rings per Inch	7.0	----	3.1	----	.44	----
Per cent Summerwood	39	----	30	----	.77	----
Per cent Moisture	73	14	133	14	1.82	1.00
Specific Gravity—O. D. Wt.						
Volume at test	.53	.58	.42	.48	.79	.83
Volume O. D.	----	.63	----	.51	----	.81
Per cent Shrinkage (Radial)	5.6	----	4.2	----	.75	----
Static Bending						
Stress at Proportional Limit	4930	9200	3200	3900	.66	.43
Modulus of Rupture	8800	15,140	5800	8100	.66	.56
Modulus of Elasticity	1640	2068	900	1080	.55	.52
Work to Proportional Limit	.85	2.30	.68	.81	.80	.36
Compression Parallel to Grain						
Stress at Proportional Limit	2830	6090	3000	4600	1.07	.99
Maximum Crushing Strength	4400	8060	4400	8000	.77	.99
Compression Perpendicular to Grain						
Stress at Proportional Limit	660	1177	400	770	.59	.65
Hardness						
End	559	899	400	620	.71	.66
Side	570	879	430	550	.74	.64
Shear Parallel to Grain						
Maximum Shearing Strength	920	1582	820	1500	.89	.95
Cleavage						
Load to Cause Splitting	244	296	170	230	.70	.78
Tension Perpendicular to Grain						
Maximum Tensile Strength	403	550	320	250	.79	.93

*Markwardt, L. J. and Wilson, T. R. C. 1935. Strength and Related Properties of Woods Grown in the United States. USDA Tech. Bull. No. 479. (Data used for slash pine from St. Tammany Parish, Louisiana.)

sion is also indicated by the results reported by Olson et al[5].

Use of Punched Card Techniques

Punch card techniques provide a very suitable method for the summarization and analysis of data obtained from strength property tests of wood. The principal features of the system which lead to a recommendation of its use relate to its rapidity, economy, accuracy, and versatility. The following brief explanation is intended to elaborate these points. The procedure for use in the case at hand is broken into four major steps.

The coding of data for punching was done by persons thoroughly familiar with the test data involved. This coding consisted of preparing a data sheet for each individual test piece for both the green and air-dry samples. Numbers were assigned to each of the identifying factors and actual values given to each of the tested variables. This coding is necessary to put all of the information into a form which the machines can utilize.

The second step consisted of the preparation of punched cards from each of the coded sheets. The cards were punched by one operator and then verified by another to insure accuracy. This is essential. Approximately 1000 cards were prepared in about 2½ man days.

The third step comprised the preparation of preliminary summaries. These data enabled the experimenter to recommend specific analysis procedure. The summaries were prepared in the form of printed sheets with the information grouped in various ways to provide a rapid visual check of the several aspects of the problem. The fact that the information is on punched cards permits efficient rearrangement of the data in the different forms requested by the experimenter.

The fourth step was the statistical analysis of the data. A review of the preliminary summaries substantiated a proposed initial analysis schedule. For example, it showed the need for analysis of variance pattern to test the significance of the source location of the sample material; also, a multiple correlation analysis of the effect of measured variables on strength properties. At several points in the analysis procedure, the results indicated the desirability of supplementary analyses which were made without difficulty because of the flexibility and the rapidity of machine methods. The total analysis procedure required 3 man days of intermittent time.

In the statistical analysis all calculations were made and checked on an IBM-604 electronic calculating punch. The analysis consisted of analysis of variance, correlation, and multiple regression. The machines computed r and then solved the simultaneous equations and computed R. Checks are provided to minimize the occurrence of errors.

The subject project required approximately 1000 manually punched cards for basic data and approximately 9000 punch cards were automatically reproduced without manual punching for use in the subsequent analysis. The punch card approach has several advantages in that the cards serve as a permanent file record of the project. Additional data can be added from time to time and new analyses made when convenient or desirable.

The entire IBM process connected with this project was carried out on a bona fide fee basis. The total charge amounted to $240. This is realistically economical in view of the volume of data handled and the statistical complexity of the analysis performed. Naturally, considerable analysis work was undertaken which does not appear in the report. The real benefit occurs through the versatility of machines to explore all possible paths of analysis in a rapid manner.

Conclusions

1. Plantation-grown slash pine of the age, size, and growth character of that tested does not exhibit normal strength properties for the species. It is logical to suspect that the condition is not a consequence of the plantation origin of the wood.

2. The strength properties of the plantation-grown slash pine tested in this study were found to be of an inherently variable character.

3. Location was found to be a significant factor in relation to strength properties. It is probable that the locations are related to those variables influencing strength properties by some indiscernible mechanism. Seed source and plantation management practices are suggested as other factors related to the development of strength properties.

4. It is evident that the strength property variation (a) within trees, (b) within locations, and (c) between locations represent themselves in increasing order of magnitude. This is an argument against repetitive tree sampling as a procedure in determining species means.

5. Only a very limited portion of the variation in strength properties can be ascribed to the commonly-considered variables of (a) number of rings per inch, (b) per cent summerwood, and (c) per cent moisture content.

6. Simple correlations on a "within-location" basis were usually found to develop nearly as reliable indications of strength properties as did multiple correlations. This is judged by the correlations of number of rings per inch, per cent summerwood, and moisture content with modulus of rupture, maximum crushing strength, and maximum shearing strength.

7. This was further substantiated by measuring the "direct" influence of one independent variable by reducing the other two to constancy. The results showed that the "direct" effect usually accounted for nearly all of the total effect.

8. The factors ordinarily associated with the variability of strength properties in wood appear to be of only intermittent significance as to their predictive value with reference to modulus of rupture, maximum crushing strength, and maximum shearing strength.

9. The use of punched card procedures in the analysis of data resulting from strength property tests of wood is highly recommended.

Discussion

D. W. Bensend (Iowa State College): If the data were separated on the basis of number of rings from the pith and the number of rings per inch, how would plantation-grown pine compare with natural grown timber?

Mr. Kramer: Age is important. If the data were separated according to ring distance from the pith, you probably would get better correlation. In other words, plantation-grown wood is not as bad as we first thought it might be.

Mr. Bensend: What part does fibril angle play in determining strength properties?

Mr. Kramer: It appears to have a definite bearing on strength properties.

Eric A. Anderson (State U. of N. Y. College of Forestry): Did you eliminate such defects as pitch, compression wood, and excessive slope of grain from the test specimens?

Mr. Kramer: We eliminated adversities of grain, pitch, or brash characteristics. We made an initial culling and then re-examined those with irregular data to be sure no irregular samples were included in the data.

W. I. West (Oregon State College): What techniques were employed to determine the percentage of summerwood?

Mr. Kramer: By cumulative measurement over the test piece with tolerance of .025 inch.

[5] *Op. cit.*

Production Control for Maximum Machine Efficiency[1]

R. F. WILDER

Plant Manager, The Mengel Company, Louisville, Ky.

In planning for maximum efficiency in a furniture plant, it is first necessary to have an overall basic plan for the entire organization. Planning should be directed toward key departments through which all material must flow; then focal points should be established within individual departments. Requirements are listed which are essential for supervisors in properly scheduling work through their departments.

PRODUCTION CONTROL for maximum machine efficiency may be defined as maximum input plus maximum output with minimum bottlenecks. It is necessary to include "minimum bottlenecks" because there are bound to be some, regardless of how well a job is planned.

A number of points will be illustrated by practices followed in the Furniture Division of The Mengel Company. We have one rough mill which makes all solid parts including cores and carries on operations through the planers, stickers, or molders. The material fans out of the rough mill to either the plywood department for fabricating of panels and cutting to rough size or to the machine mill where all machining operations are performed up through polish sanding and a certain amount of sub-assembly such as dust panels, doweling, base assembly, etc.

From the machine mill, the stock moves to one of three assembly departments, through there, and into one of three finish departments where two finish lines converge to one packing department and the third finish line to its separate packing department. From these packing points, a mon-o-rail conveyor picks up all merchandise and delivers it to the warehouse.

To obtain the objective of production control for maximum machine efficiency, it is first necessary to have an overall basic plan for the plant or organization as a whole. If the operation in total is not well planned, then there is not going to be maximum input in any individual department, which certainly will prevent maximum output. Therefore, it will be necessary for complete and detailed overall planning, which certainly must be all inclusive from the lumber yard through to the warehousing of the finished product.

Considering a furniture factory, there are certain basic plans in the following outline which will be applicable to any manufacturing organization.

First of all, even in the plant itself there are certain basic or key points. A large percentage of thinking must be given to the cross cut saws and to the cabinet or assembly departments on the theory that if the lumber is not cut off in the right volume and in the right sequence, then no subsequent departments are going to function properly. On the other hand, if the proper volume moves through the cross cut saws, then flow through subsequent machining operations is going to be much more easily obtained.

Focal Point

In the cabinet room, if material is not assembled in the right volume and the right sequence, the finishing department is certainly not going to finish it, pack it, and ship it. The question might be asked as to why the cabinet room is more important than any other department and actually maybe it is not any more important in relation to the final job. However, from the standpoint of planning for maximum efficiency, the cabinet room is more important because at this point everything is focal and all of the multitude of parts which go to make up a suite of furniture must of necessity gravitate to this area. Not only is there a push first on the part of the machine mill room to move these parts to this area, but the cabinet room must act as a magnetic force in pulling them into focus for assembly.

Thus here is a department through which every part must pass before the final product begins to assume any degree of completion. If planning is directed toward this point, then everyone in the entire plant is pointing in that direction and acting accordingly.

Going from the whole to the part, the same line of reasoning can be used in relationship to the individual departments. Focal or key points should be established in these individual departments with the underlying theory that if those key points operate efficiently, the rest of the departments will take the work away, barring of course, unusual circumstances, breakdowns, etc..

Therefore, the next logical step is to study each individual department and pick out one or possibly two such areas which will enable one to keep his pulse on the operation of the department itself without having to go into too much detail. For example, the cross cut saws were mentioned in relationship to the plant as a whole and obviously they are equally important to the control of the operation of the rough mill.

As the cross cut saws are important to the rough mill, so are the double-end tenoners to the machine mill. As a general rule, if the double-ends are operating efficiently, it is reasonably certain that the rest of the mill is going to be properly fed with stock so that the individual machining operations can be performed without any undue delay or lost motion.

The key points in the cabinet rooms are the case clamps and in conveyorized finish systems they are the conveyor loading points. Therefore, the second important factor is the selection of key points in an individual department geared to the first point of basic overall planning.

Some companies compile a great deal of information as to available machine hours in various departments, chart the schedule or production load against these machine hours, and with a rather elaborate system of production control, set up the progress of the work through a department. Perhaps this is not the best way to handle planning for individual machines. Among other things, it requires a fairly elaborate engineering setup and with competition the way it is today, perhaps the furniture industry can not afford such an expense.

In planning for maximum efficiency, certain things are absolutely necessary in order for it to work. To a large extent, it is necessary to rely on supervisors to properly plan the work through their departments and in order for this to be accomplished, there are certain requirements which must be fulfilled.

1. The caliber of the supervisor must be such that he can adequately handle his department.

2. Tied in to the basic overall planning, there must be a detailed schedule breakdown which, though it

[1] Presented at meeting of Great Lakes Section, FPRS Dec. 1–2, 1954, in Grand Rapids, Mich.

does not have to be complicated, must show starting and completion dates of various releases or cuttings in relationship to various departments.

3. Such information in the form of part sheets or any convenient way to present it must be in the hands of the supervisors so that the work can be followed through their particular departments and the necessary steps taken to see that material is at the right machine at the right time.

4. All foremen and expediters must be thoroughly familiar with the overall schedule; lines of communication must be such that they are completely informed of progress and any changes which become necessary.

5. A sequence of items must be established. When a release is started in work, certain items must always be cut first and that sequence not be upset from the time the first board is cut off until that case or item goes into the assembly department. In our plant, for example, parts for three items must be delivered to the cabinet room on the starting assembly date: the triple dresser, double bed, and a mirror frame or night stand. The next items on the list are the double dresser and a low footboard bed; the next are a chest and bookcase bed, and so on down the line.

6. A time cycle or at least an average time cycle must be established by the various major departments. In our plant, the most time allowed on an average size cutting is 13 days from the time the cutting is at the cross cut saws until it is ready for assembly.

7. Size of cuttings and number of individual items in a given cutting are important for maximum machine efficiency, particularly where involved or complicated machine setups have to be made. The type of plant operated influences in a large measure how big cuttings should be. Normally the bigger the cutting the better. However, in our plant this is not true because the machine departments must operate three cabinet rooms and if cuttings are too big, one cabinet room is oversupplied with parts but either one or both of the remaining two are likely to run out of work.

8. Frequent check-ups on the part of expediters within the department and between departments must be made.

9. An overall method of daily check-up on individual departments as well as plant-wide progress must be devised. These vary widely with different plants. The system we use is very effective for our particular needs. To start with, progress in each department is measured in some kind of units. In the rough and machine mills, the units are net feet, in the plywood department the units are slab feet, and in the assembly, finish, and packing departments, they are sales dollars. Next production is related on a per man basis and it is known for each department how many units per man are necessary each day to meet the departmental schedule. It is also known each day how much labor costs by departments were the day before and how the amount which was spent compared to the amount which was allowed. Overall plant progress can be easily determined by these daily reports where it is possible to determine total labor efficiency, production per man expressed in sales dollars, and performance against schedule.

The foregoing is of a very general nature and no statistics have been given of how many pieces a horizontal boring machine should handle per hour, how many thousand feet should go through a three-drum sander per hour, and so on. We do not run our plant from an overall standpoint in relationship to such figures but we do know what a machine should produce.

Even though at the present time we are on day work, we used to be on piece work and still use former piecework rates as a measure of efficiency from time to time at the discretion of the general foreman of the department. This helps to determine if certain operations are being done at the best rate of efficiency. Figures such as these are a tool to be used by supervision as a means toward accomplishing the end result set forth in our basic planning.

On-the-Job Orientation Training for Technical Personnel[1]

L. F. MAYBACH

Project Engineer, Crown Zellerbach Corp., Antioch, Calif.

Describes operation of Camas Paper School operated since 1933 by Crown Zellerbach Corp. Purpose of four-year program is to assist employees in gaining understanding of duties and preparing for advancement. The first two years are concerned with fundamentals of pulp and paper manufacture and cover the entire mill operation. The third and fourth years give more specific knowledge of the manufacturing processes and allow the student to familiarize himself with each operating department.

IN THE FALL of 1933, some of our people with more than average vision organized a class for employees of the Camas Mill with the following stated purpose:

"This course is intended to assist the employees in various departments of the mill to more clearly understand their present duties and to prepare for advancement to more responsible positions. Particular emphasis will be laid on the mill operations affecting the quality of product, and it is expected that the course will aid materially in creating a quailty-consciousness among the students. The study will not be solely technical, but also will include sufficient subjects of management nature to engender in the student an appreciation of industrial economics and company policy."

The original estimate was for a class limited to 40 students selected from applicants on a departmental basis by supervisors. When 190 applications were received, the limited class idea was discarded and the class was opened to all employees of Crown Zellerbach Corporation in this area. This policy

[1] Presented at Session VIII, Education, EPRS Ninth National Meeting, June 21–24, 1955, in Seattle, Wash.

The Author: L. F. Maybach, a graduate of Oregon State College, has been employed by Crown Zellerbach since 1933 except for four years' Army service in World War II. Formerly project engineer for processes at the Camas, Wash. division, he was professor in the paper school from 1945–53, dean of the paper school in 1954–55. Maybach was transferred to the new Antioch division in Sept. 1955.

is still in force and many students come to Camas from other nearby divisions to take part in this project.

The first class was organized to give the student a complete orientation in one year by attending 24 classes. This orientation appeared to only whet the appetite of the students, and by popular demand the second year was added, then a third and fourth year in turn. With the additional classes the field of study was broadened to include material outside the mill proper, but always related to our primary industry—papermaking.

Organization

The school organization developed and grew with the expansion of the curriculum and became stabilized at an early date in its present form. Executive supervision and direction of the Crown Zellerbach Paper School policy is exercised through a board of regents of three members—a vice-president, the Camas resident manager, and the West Linn resident manager. The immediate control and direction of curriculum and instruction is assigned to a supervisor in the mill who is given the title of dean of the school. The dean is assisted by an associate dean and a principal. Originally these positions were held by men with technical background. At present the dean is a project engineer for mill processes, the associate dean is an assistant resident manager, and the principal is the plant industrial engineer. The personnel chosen for these positions must have broad experience within the mill and have a centralized view of the entire mill operation.

One professor for each course is appointed by the dean, associate dean, principal, and board of regents, and an associate professor is likewise chosen for each class. Five advisory faculty board members, who are chosen because of direct contact with the various departments, make themselves available for any information or assistance that is required of them.

The staff is rounded out with two administrative assistants who take care of the school properties such as visual aids, maintain the equipment—movie projector, slide projectors, etc., check attendance at classes, and supervise the technical tours. Permanent records are maintained in the mill office by a regularly employed stenographer. All stenographic work is accomplished in the mill office and this sometimes becomes a full time job during the school year when about 300 students are enrolled in the four classes.

The staff takes care of the administration, with the professors and their assistants directing their respective classes, advising the students, and regularly checking their progress by examinations. These examinations are carefully constructed to emphasize the basic points of the process being considered, and the results are carefully recorded to be used as a measure of student progress as well as a measure of school effectiveness.

Valuable Instruction Method

The success of the school is probably the result of the incorporated foreman-employee relationship that has developed. This relationship, the value of which is now clearly recognized, has arisen from the method of instruction chosen at the outset and was not deliberately conceived in the first classes. We refer to the concept of the school whereby the mill superintendents and foremen are the lecturers and instructors in their particular fields, without recourse to formal method of textbook instruction. Obviously, the simultaneous conduct of four paper school classes places a heavy demand upon extra time of those charged with the responsibility of carrying on the paper school. A natural temptation is to resort to the more normal method of instruction and place the material with one or two well qualified teachers to impart the information to students with the usual schoolroom efficiency. The professional-teacher method would be far less effective than the present system.

On the other hand, Camas mill superintendents and foremen have themselves become increasingly proficient in their presentations of subject matter. In preparing for these presentations, it is necessary for them to review carefully their entire sphere of influence and the process for which they are responsible. Since all classes are conducted on a conference basis, the instructor must be prepared for some pretty sharp questions and often must review his process in the light of suggestions raised on the classroom floor.

A textbook called "Making Paper" has been compiled from transcripts of the lectures given by men who are skilled, each in his own field. This book furnishes a complete reference for the student to pursue in collaboration with his current lecture. This text is now in its third edition and quite different from the first edition, which was made up of a loose-leaf file of lecture notes.

You have probably recognized by this time that this school has something in common with all other worthwhile efforts: it costs time and money. Without the liberal policy adopted early by the mill management in respect to financial outlay annually for its conduct and maintenance, the school would close its books. No charge whatever is made to the student. He is provided with a copy of the textbook which he is required to return at the end of the school year. If he wishes to buy this text, he may do so. Flow diagrams, charts, slides, motion pictures, and drawings are made for each lecture where they will help instruct. These are edited each year, brought up to date, and filed to continually expand the data available.

Course Schedule

The instruction is broken down into four classes which must be taken in turn, one each year, so the student will have completed the course in four years. The first- and second-year classes are open to all employees, both male and female; the third and fourth years are restricted to male employees.

The aim of the first two years is to ground the men and women students with a broad, general picture in the fundamentals of pulp and paper manufacture. The course is designed to be helpful to employees regardless of educational advantages.

The first year includes lectures on the Crown Zellerbach Corporation organization, logging operations, wood supply, wood mill operations, water supply, basic materials and principles, groundwood mill operations, kraft mill operations, sulfite mill operations, pulp screening, sulfite bleaching, kraft bleaching, control of pulping, special developments in chemical pulping, industrial engineering, industrial instrumentation, and industrial and community relations. To aid in instruction, conducted tours are made to the wood mill, water supply, kraft mill (two tours, one to the digesters and washers, one to the recovery system), sulfite mill, sulfite bleach plant, and kraft bleach plant. These visits are made immediately following the lecture on the respective operation so that the student may actually see the process being considered. The first year ends with the study of the pulping processes.

The second-year class covers that part of the paper-making process not covered in the first year and includes lectures on use of steam and electric power, research and development, beater room operation, mill maintenance, paper machines and refining stock, wrapping paper manufacture, tissue paper manufacture, paper testing and instruments, paper finishing and supercalendering, paper grades and specifications, paper converting—towel, toilet tissue, facial, waxed lunch roll and napkins, bag factory and printing, sale of Crown Zellerbach products, production planning, shipping and warehousing, purchasing and account-

ing, and mill management. With these lectures, conducted tours are made to the Crown Zellerbach Research and Development laboratories (located at Camas), beater room, wrapping machine rooms, tissue machine rooms, finishing departments, converting and napkin departments, and the bag factory and printing department.

Completion of these two years will have taken the student through the entire mill operations from log to shipment of packaged product.

Individual Mill Study

The third- and fourth-year classes composed of men only give the students an opportunity to gain more specific and detailed knowledge of the manufacturing processes and associated activities, and by individual mill study allow the student to familiarize himself with each operating department so that he might better qualify himself for advancement.

Progress in the third and fourth years is more dependent upon the student's initiative as only eight or nine lecture- or conference-type meetings are held. The lectures for the most part are prepared and presented by outside speakers and cover subjects allied to paper manufacture. These contacts, with men entirely apart from paper production, provide the students with new viewpoints which lead to a broader scope of understanding.

In addition to attendance at the scheduled lectures, each student is required to spend four hours a week or a total of 64 hours per term in mill study, allocated 16 hours each to wood mill, kraft mill, sulfite mill, and beater operations in regular progression. Four evenings are devoted to general discussion of problems in these departments, the supervision of the department in question taking the chair.

The mill studies required of this class are on an entirely different basis than the supervised mill visits of the first two years. The student is provided with a pass which admits him to all departments of the mill for his study at any time, day or night. His aim is to apply himself to the particular department being studied as though he were preparing himself to become a responsible operating foreman. To be sure, this idea is scarcely fully realized except in the case of the more competent individuals; yet it is surprising how well the student trains himself, for example, in the knowledge of wood preparation or pulp manufacture, and develops his powers of observation and interpretation. The student is privileged to ask questions in each department of any operator or workman whom he may come in contact with so long as he does not directly interfere with production or create a safety hazard.

Outside subjects covered in the third year are: operation of tree farms, use of the electron microscope in wood study, materials of construction, Zellerbach Paper Company operations, and mixing and blending materials.

A field trip is also conducted for this class to one of the mills using Camas paper products, such as Western Waxed Division at North Portland, Oregon.

As in the first two years, each quarter is covered by an examination, the results determining the relative standing of students.

The fourth year is conducted similarly to the third year. The third-year graduate continues his independent line of study but it is applied to phases of types and operation of paper machines and stock preparation, finishing and converting of paper and shipping, steam, electrical and mechanical departments, quality control and its relation to paper products, and final use of these products. This subject requires an understanding of the entire subject of technical control.

As in the third year, outside speakers are invited to speak on subjects disassociated with the industry, but different from those discussed in the previous year, such as wage economics, hydraulics and pumping, evaporation, business principles, and practices of management.

The fourth year class is also taken on a field trip, usually to the West Linn division that makes use of processes not seen at Camas.

All third- and fourth-year students, except those from West Linn, make their mill studies at the Camas mill. West Linn conducts a program for their students. They are required, however, to attend the third- and fourth-year lectures at Camas. This arrangement was made to give them a better understanding of the processes at West Linn which are dissimilar to ours as well as solve a transportation problem.

Other divisions represented at the paper school this year are: St. Helens, Waterway Terminals, Western Waxed Division-North Portland, Mollala Logging Division, and Portland office.

Results of Program

Statistically, 1,560 students have completed one year, 935 have completed two years, 513 have completed three years, and 392 have completed four years.

Results are fogged with a lack of clear-cut measurements. We are sure much factual information is observed, and graduates are able to talk intelligently about any part of the mill with representatives from any other department or paper mill. We promise no advancement to graduates based on paper school activities, but there is a peculiar positive correlation between success in school and on the job. There is some argument whether the individual succeeds because of paper school, or would have succeeded without it.

Successful completion, of course, places the individual before supervisors who may be looking for someone to fill a particular job and, all other things being equal, a supervisor is likely to favor a paper school graduate over a non-graduate. The school is another link in the communications net that is necessary for coordinated effort in a large industry. It is thought that individuals who have completed paper school can more easily be moved from one department to another. These graduates are also called upon to act as guides for some of the many visitors who tour the mill.

The faculty would like to have a better evaluation than we have been able to obtain. The best available to date has been the continued willingness of management to supply the funds necessary for operation of the school.

Discussion

W. R. Smith (Southeastern Forest Experiment Station): Is your program carried on in the evening and on the employees' own time?

Mr. Maybach: Right! Classes meet from 7:30 to 9:30 p.m. All are conducted on the personnel's own time.

J. S. Bethel (N. C. State): Your group must represent several academic levels. Do you find it difficult to keep all in attendance?

Mr. Maybach: We have a drop of about 25 per cent in the first year. Individuals without aptitudes will give it up. Courses with 135 enrollees will end up with about 100. At the end of the fourth year, we graduate about 20.

Dr. Bethel: Do your chemists and engineers go through this training session?

Mr. Maybach: Yes, and they usually complete the 4-year program. The training doesn't attempt to fit a man for a job, doesn't point up for a particular job either. It merely helps individuals to appreciate and more fully understand each other's job, and gives them a better appreciation of our operations and what others are doing. Of course, there are many indirect and intangible benefits to be derived from the program.

W. R. Smith: Is total attendance and a grade required for graduation?

Mr. Maybach: A grade of 70% and attendance of 70% of the scheduled hours are required. If working when

classes are scheduled, the worker is automatically excused without penalty.

A. J. Panshin (Michigan State U.): Do you notice any improvements in production which may be attributed to the training program?

Mr. Maybach: I would like to be able to say yes—but we can make no claim for quality standards—we simply don't know.

Dr. Panshin: Do you notice any tendency to lose your graduates?

Mr. Maybach: Yes, we lose a few to other mills. Actually, our graduate lists do show people in responsible positions. On the other hand, we make no claims that the school was responsible. Pride of company is a real asset, however.

Dr. Panshin: What effect has the school on labor relations?

Mr. Maybach: We make no claims on this point. We do, however, have good labor relations, but if the school is responsible, I can't say. We urge supervisors to be a part of the faculty, and in this way they become better acquainted with the students. Perhaps this relationship prevents a lack of interest and provides for better communication between the supervisor and his subordinates.

M. H. Mater (Mater Engineering): What are the goals of this program?

Mr. Maybach: We do not train for specific jobs. The fact that the student makes some personal sacrifice makes him take an interest and probably he does a better job. You must appreciate that this kind of training is purely voluntary and costs the company about $10,000 annually.

Professional Development of Technical Personnel On the Job[1]

R. E. BAKER

Manager of Manufacturing, Pulp Division, Weyerhaeuser Timber Co., Longview, Wash.

Discusses on-the-job training methods used by the Pulp Division of Weyerhaeuser Timber Co. to provide growth opportunities for college technical graduates. Stress is placed on variation of actual experience and assignment of responsibility. It is believed that most progress is made by personnel who are capable of and who assume continually more responsibility.

IT HAS BECOME increasingly apparent that the development of personnel is one of the most pressing problems facing industry today. Practically every company is spending more and more effort and energy toward the goal of having suitable replacements for existing jobs or qualified candidates for new jobs as they may be needed. The spectacular growth of industry, and particularly the forest products industry, has emphasized the urgency of this problem.

In an industry such as pulp and paper, which is primarily a chemical process, it is only logical that emphasis is on training and development of technical personnel, although it is not meant to minimize the importance of the other professions and trades. It is well recognized that there is an acute shortage of chemical and engineering graduates. Also, it is to this group that the pulp and paper industry looks first in its quest for supervisory and management personnel. Because of this, it behooves the industry to exert its best efforts in the development of technical people on the job.

In a program of development of technical personnel, a company must first of all select the personnel. Granted that there may be various levels of responsibility to have filled with technically trained people, the company is still concerned fundamentally with the individual who aspires to leadership and who has a personal determination to undertake a program of self-development.

Recruiting Personnel

Because of these facts, we place great emphasis on selection of people believed to have this self-determination as well as already proven technical ability. Rather than have all technical people recruited in a routine manner, we attempt to get many by personal contact and interviews of department heads or higher. It is, as stated previously, first of all necessary to obtain people who have the inner desire, ambition, and willingness to assume responsibilities and further their own advancement.

Having acquired the technical graduate who has the above attributes, it is then our responsibility to place him in a position which provides primarily an opportunity for him to advance. In the pulp division of our company, we prefer first to assign these people work along the lines that utilize their college training. If they are chemical engineers, undoubtedly they will be given a specific investigative or development project relating to mill operation. It will be one designed to tax their ability to organize as well as carry out technical details of a problem. These projects are of a nature that will broaden and develop the individual's capabilities and at the same time require the exercise of intelligent thought and decision. Also, they present the opportunity for advancement to greater responsibility as they are able to carry it out.

Although the college training of the technical man may be good and an excellent start, it is necessary that demands be made, not only on mechanical skills which he has acquired, but more importantly on his developed skill to organize and carry out a project of no little importance. We believe that this should be done early in his career, since time lost in the development of any individual cannot be regained.

Given Added Responsibility

As technical personnel become more familiar with the various phases of the operation and demonstrate ability to assume responsibility as well as to get along with other employees, we give them opportunity as supervisors of operating departments. It is only by this actual experience in operation that a technically trained man can become able to appreciate the other fellow's problem. It also affords him the opportunity to broaden his own experience

[1] Presented at Session VIII, Education, FPRS Ninth National Meeting, June 21–24, 1955, in Seattle, Wash.

The Author: Raymond E. Baker received A.B. from DePauw U., M.S. and Ph.D. degrees from Institute of Paper Chemistry. He was associated with Brown Co., Munising Paper Co., and Diamond Match Co. before joining Weyerhaeuser in 1947 as Longview Mill Manager. Baker was promoted to his present position in [illegible].

and acquire more of the techniques of leadership.

Assuming that this technically trained man may then be moved back into the engineering or technical department, he will be in a much better position and better qualified to assume additional technical responsibilities. Having had the supervisory experience, he will naturally keep in closer touch with operations, and have a better appreciation of the various problems as they may arise.

We have, over the past few years, carried out various auxiliary programs, for our technical as well as other supervisory people, designed to augment their actual on-the-job training. These have covered subjects such as human relations and communications. Besides these activities, we encourage active participation in technical societies, community projects, and other self-development activities.

We maintain an inventory of these technical people as well as other supervisory personnel who either presently or potentially in the future are capable of being promoted to more responsible positions. This inventory consists of a rating of the individual, and it is periodically reviewed in order to plan better the steps which should be taken to improve their ability.

We follow the concept that it is good practice from the standpoint of development of our personnel to maintain a flexible job progression. In this manner, we are able to give technical people the opportunity to obtain a more varied experience and knowledge, as well as to assume greater responsibilities. It is because of this belief that practical experience and the development of leadership qualities are most important that most efforts are directed to the assignment of definite problems and responsibilities.

Vital Factor

In an American Management Association publication entitled *Management Education in American Business,* by Lyndall F. Urwick, the practical factor is described as follows:

"It has been emphasized throughout this report that—important and, indeed, essential as is the intellectual factor in the development of future leaders—the practical factor is even more vital. This is so for the simple reason that, in the type of personality which others will accept willingly as their leader, character is an even more critical element than are mental attainments. And character is developed primarily on the job, in the give-and-take of being responsible for the work of others and being held accountable for results oneself, through making mistakes and gaining wisdom from them, from the example of equals, superiors and subordinates, by 'Meeting with Triumph and Disaster' and treating 'Those two impostors just the same'. In fact, as has been well said, 'the workshop of character is everyday life,' and it is only in an everyday life of progressive responsibilities that men can learn that combination of vision in conception, singleness of purpose, and realism in judgment which will equip them to play a principal part in the economic life of the community."

We subscribe wholeheartedly to that thesis, and diligently attempt to provide all the help we can so that the individual will be given opportunity to develop the needed character.

Discussion

J. S. Bethel (N. C. State College): Do you see any possibility of graduate technical personnel returning to the campus for additional training?

Mr. Baker: Yes. We have, for example, had men go to Harvard Business School.

R. W. Wellwood (U. of British Columbia): On the matter of vocational training as it relates to the college student, one might point out that a limited amount of this kind of training can be accomplished during the summer vacation. The educators have only a limited control of this phase of education but can guide undergraduates as to broadening their training.

Roy M. Carter (N. C. State College): The exceptionally well organized and executed in-service-training programs described today are good examples of policies more wood industries should be following. Unfortunately, they do not represent the usual type of on-the-job training program for new employees or graduates of wood technology curricula. The furniture, plywood, lumber, and allied wood industries want men that can step into their plant and do productive jobs within a very short period of time. They do not have, or do not fully appreciate, the need for an adequate plant training program.

Frequently, the most impressive graduate is the man who can operate machines or do other production jobs on a line with other employees. Not only does he command the respect of the production worker but the supervisory personnel, too. Very often plant management thinks more highly of this man than the graduate with excellent technical education who is not familiar with their production methods. But if this newly employed graduate who can immediately fit into the organization is also technically competent, he will be much more valuable to the industry. The latter is the type of man we are attempting to train for the wood industries in our wood technology curricula.

We are therefore compelled in our forest products training to make a satisfactory and perhaps even a healthy compromise between the most fundamental basic technical training and vocational training. People still learn by doing and the technical knowledge in lectures and texts, if supplemented by laboratory work, improves the process of education. If we did not include laboratory exercises and experience in wood conversion and fabrication methods, we probably would have some difficulty in placing graduates, which is not the case now.

Until the wood industries are in a postion to provide adequate training in their specialized plant, our forest products or wood technology curricula must provide a good fundamental basic training supplemented with specialized courses to prepare the student for satisfactory employment during the first few years after graduation. As the transition of the industry takes place and conditions warrant changes, the educational programs for the wood industries should be modified to include more basic type courses and less of the strictly vocational or applied type of course work.

Durability of Radio-Frequency Bonded Urea Resin Joints[1]

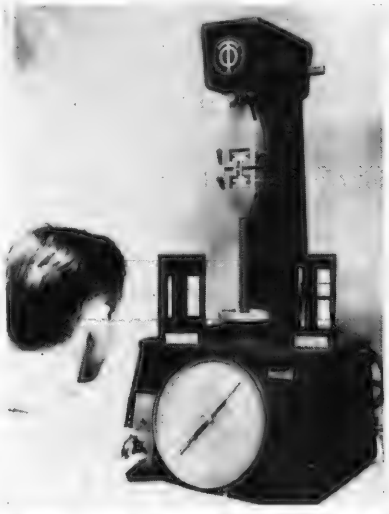
Describes a study to determine whether rapid curing of urea-resin joints by dielectric heating affects the durability of the joints. Results showed no significant difference between pieces bonded by dielectric heating and hot-pressed pieces. All joints were considered highly satisfactory after accelerated aging tests.

SOON AFTER THE INTRODUCTION of dielectric heating in the wood-using industries, there arose some doubts as to the durability of glued joints bonded by this method. Reports were received of joints, made with urea resin glues and bonded by dielectric heating, having failed soon after they were put into service. In many cases these failures were attributed to the use of dielectric heating for curing the glues. In view of these reported failures, an investigation was undertaken by the Ottawa Laboratory, Forest Products Laboratories of Canada, to determine whether the rapid curing of urea resin glues by means of dielectric heating, is detrimental to the durability of the resulting joints.

Yellow birch at a moisture content of 6 per cent and a typical urea resin glue were used to prepare edge-glued joints. The glue was mixed and spread according to the glue manufacturer's recommendations. Test pieces were bonded by dielectric heating. Curing periods of 2 min., 1 min., 30 secs., and 15 secs. were used. In each case, only sufficient radio-frequency power was used to satisfactorily cure the glue in the specified time.

Four different curing times were used in order to assess any influence that the rate of cure might have on the quality of the resulting joints. In addition, test pieces were also prepared by cold clamping, and by hot pressing between electrically heated platens. The hot press samples were bonded at a platen temperature of 212° F.

To obtain information quickly on the quality of the various joints, accelerated aging tests were carried out with some of the test pieces. Two different accelerated tests were employed: one, a cyclic soak-dry test, and the other, exposure in a weatherometer.



Strength testing machine used in evaluating r.f. bonded urea resin joints.

Results

Results of these tests indicated a slightly greater deterioration of all joints bonded by heat application than of those bonded by cold clamping. There was no significant difference between results obtained with pieces which were hot pressed or those which were bonded by dielectric heating with any of the four heating cycles. The accelerated tests used were very severe for this type of glue, and all joints were considered highly satisfactory.

The remainder of the test pieces were retained for natural aging and stored under normal indoor room conditions. Of these, one group was tested after 6 months, a second group after 1½ years, and a third group has recently been tested after 5 years aging. None of these tests has shown any apparent deterioration of the joints bonded by any of the methods described. Sufficient test samples remain to continue the natural aging tests up to a period of 10 years.

Based on the results of these tests, it would appear that the reported joint failures cannot be justly attributed to the use of dielectric heating. It is probable that they resulted from incorrect operation of the radio frequency equipment or from improper gluing practices.

[1] A contribution from the Forest Products Laboratories of Canada, Forestry Branch, Department of Northern Affairs and National Resources, Ottawa.

Technology of Wood and Wood-Base Materials, Vol. II[1]

FRANZ KOLLMANN

THE MASTERY OF THIS VOLUME will require both a strong mind and a strong back. It contains 1200 pages of highly technical information and weighs 6 pounds. Indeed this is a book that will not be read by most wood technologists, but must be considered a key reference work by all.

This volume deals with the treating and processing of wood, including wood products such as particle board and various types of wood assemblies. Considered together with volume I, which appeared in 1951 and deals with wood anatomy, pathology, chemistry, physics, and strength, Kollmann's product is the most complete reference work on wood technology ever to be published.

The present volume covers the subjects of wood preservation, fire retardant treatments, and stabilizing treatments, surface treatment and finishing of wood; drying, steaming, and wood-moisture relations; improving wood through impregnation; veneer, plywood, and laminated wood; wood fiber and particle board; sawing and machining of wood; nail, screw, bolt, dowel, and connector joints; glue joints and gluing; and waste utilization.

The greatest single change to be seen in comparing this volume to the first edition (published in 1936) is the addition of a section of almost 150 pages on the types, fabrication, and testing of particle board and related new products. The various processes for making boards, many of which have had their origin in Europe, are discussed and illustrated in considerable detail. Both the wet-process boards made of wood and wood fibers and pulp and the dry boards made of shavings, sawdust, and the like are covered. This section will serve as a review of European processes and techniques for a rapidly growing American board industry.

The section on glues and glue joints has grown tremendously from about 35 pages in the first edition to 170 pages, in proportion to the growth of technical knowledge in this field of specialization. It includes discussions of the physical and chemical aspects of adhesion, chemistry of glues, testing of glues, practice of gluing, uses, advantages, and failures of glued products, types and properties of glues, and metal-to-wood gluing. High-frequency methods and other special gluing processes are discussed.

The author has done an admirable job of organizing into a single volume information from many different sources. Occasionally one has the impression that the length of the discussion of a subject is not in correct proportion to its economic importance. Under veneer slicing, for example, only one short sentence is dedicated to slicing on the efficient American-type machine, whereas 2½ pages are taken up with discussions of the slow and inefficient horizontal European-type slicer.

The book is well documented with references. Some standards, specifications, and patents are cited, but the coverage of American references of this type is not as complete as it might be. The author, being an engineer, has a tendency to stress the engineering aspects of his subject. Higher mathematics and complicated graphs are used without consideration for the layman. In other respects the book is easily readable to one acquainted with technical German. Unlike many German technical books, sentences of 10 to 15 words occur more frequently than sentences of 10 to 15 lines.

In using the information in this book, one must remember that it is not necessarily any better than the sources of the information available to the author. Nevertheless, there are great advantages in having this summary of hundreds of individual reports originally appearing in Germany, Sweden, Australia, France, England, Finland, and the United States. The American user would do well to consider the book as a useful supplement to his own supply of American literature.

In 1936 the first edition of Kollmann's book, covering the 764 pages, was hailed as the most complete volume on the subject to appear in print up to that time. Less than 20 years later, the revision in two volumes totals to 2,200 pages. This comparison serves as a fitting comment on the growth of the science of wood technology in recent years.

H. O. FLEISCHER
U. S. Forest Products Laboratory

[1] Technology des Holzes under der Holzwerkstoffe. Zweite Auflage, zweiter Bd. 1217 pp., 1194 illus., 6 tables. Springer-Verlag, Berlin, 1955. Price DM 136.

Around the World in Forest Products Research and Development

Sawmilling in Sweden

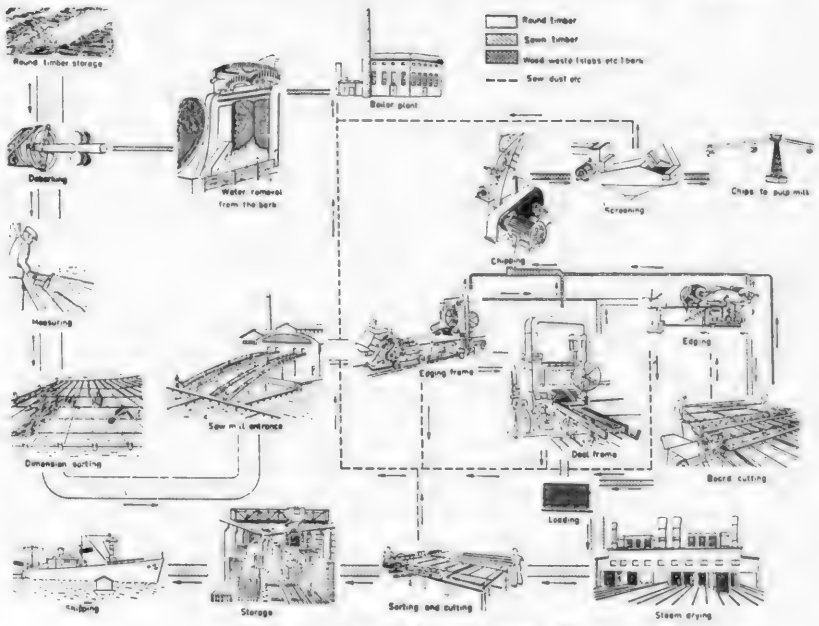
According to B. Thunell, Forest Products Research Laboratory, Stockholm, Sweden, produces some 1.5 million standards of sawn wood annually, over 64 per cent being of export grades. Two types of mills are employed, the frame-saw (gang) and circular saw mill. This abstract concerns solely the gang mill principles.

The basic production line of a Swedish frame saw mill consists of three main machines—the log edging frame, deal frame, and edger, each placed one behind the other. Larger mills have several parallel lines of which each in one shift can turn out 5,350 standards of sawn timber a year.

The series of operations is shown at right. Logs are barked, then sorted to size in the log pond. Logs of the same size are hauled into the mill on a trough chain. The log is cut into a central billet, side boards, and slabs. The side boards continue to the board edger; slabs to the waste conveyor. A lateral conveyor brings the billet to the intake rolls of the deal frame, and after adjustment the billet is introduced betwen the feed rolls and sawn to dimension. Interior boards proceed to the sorting plant; unedged boards to the board edger.

Modern log frames run at speeds between 320 and 370 strokes per minute, with stroke length of 600 millimeters. Average feed speed is 25 millimeters per minute. The number of men employed in one line is usually 14; one at log intake; 2 sawyers; 1 assistant sawyer; 2 edgers; 4 sorters; 1 grinder; 1 greaser; 1 waste cutter and 1 spare. The 8-hour capacity is 17 standards.

—Unasylva, Sept. 1955



Flow diagram of Swedish gang mill.

Canada

• In his annual report for 1954, the President of the British Columbia Lumber Manufacturers Association dramatically indicated the rapidly growing importance to the pulp and paper industry of material formerly treated as waste. The increasingly integrated forest industries of the Pacific coast, by installation of barkers and chippers to handle mill waste and logs unsuitable for sawmilling, had produced enough pulp chips in 1954 to equal the annual growth of about one million acres of productive forest land, operated on a sustained yield basis. This utilization of waste was made possible by the development of new equipment and the courage of the forest industry to spend large sums of money to install the necessary machinery.

Israel

• Since 1948, the Government and the Jewish National Fund have done an equal share of the afforestation and altogether about 40,000 acres have been planted. In the previous 35 years, the fund had planted 5 million trees.

It is estimated that the woodland will supply one-third to one-half the nation's need for timber 15 years from now. There will be enough wood for soft-board factories, part of the amount needed for kraft paper and a sufficiency of poles and posts.

Japan

• Studies on a new water-borne preservative are reported by Shigekichi Yonekawa. The preservative consists of two complex salts, ammonium copper pentachlorophenate $(C_6Cl_5O)_2$ Cu $(NH_3)_4$ and ammonium copper chromate $(NH_3)_4$ $CuCrO_4$. It is produced by mixing together with water solutions of sodium pentachlorophenate and potassium bichromate, and ammoniacal solution of copper sulphate. When impregnated into the wood, a part of the preservative combines with the wood constituents and converts into anti-fungal materials. The excess is fixed on the wood tissue as copper pentachlorophenate and copper chromate. Their copper salts are toxic and stable. The preservative has the following properties: strong toxicity, water-proofness, stability for weathering, non-poisonous, cleanliness, odorless, non-fire hazard and free paintability.

—Japan Wood Industry, V. 11, No. 3

Germany

• The greately increased volume of goods traffic between countries may be one of the reasons why many forests, particularly in industrialized regions, have in recent years become infested by a growing number of destructive insect species. On the other hand, technical development is providing more and more methods of fighting such pests. First of all, however, it is essential to know the insects that cause damage. To meet a need expressed by many practical foresters, a key has been published for identification of forest insects from pictures of the damage done to the trees, (Schimitschek, E.: *Die Bestimmung von Insektenschäden im Walde,* 1955, pp. 196, 290 illus., Paul Parey, Hamburg).

Abstracts From Current World Literature

Veneer and Plywood

Le Ray, J. Tropical timbers and veneer. *Bois For. Trop.* No. 40, 1955 (35–48).

Summarizes information collected by FAO on the production of veneer in tropical countries and the importation of tropical veneer logs by the U.S.A. and European countries. [For. Abs. V. 16, No. 4]

Rinne, V. J. The core in the plywood industry. *Pap. ja Puu* 37 (3), 1955 (71–2).

General practice in Finland has been to peel plywood logs to 80-mm. diam. and then to cut the core into pieces and to continue peeling on smaller rotary cutters to avoid bending the core. A device supporting the core has been designed which allows continuous peeling to 60 mm. [For. Abs. V. 16, No. 4]

Seasoning

W. C. Stevens and G. H. Pratt. Seasoning wood at high temperatures. *Timber Technology,* Vol. 62 No. 2186, December 1954, pp. 599–602.

Report of a series of tests carried out at the Forest Products Research Laboratory to compare drying rates and quality of both hardwoods and softwoods dried at temperatures in the region of boiling point (100° C). High temperatures, i.e. temperatures above 100° C., promote faster transfusion of moisture through the wood, thus reducing the drying time, but are usually accompanied by increase in degrade. They tend to increase shrinkage and distortion, to induce forms of collapse, and to affect adversely the strength properties. Hardwoods are generally less tolerant than softwoods.

The tests were carried out in a brick-built kiln in which temperatures up to 120° C. and an air speed of 6 ft per sec could be maintained. Seven series of tests were conducted using 1-in. and 2-in. Scots pine, 2-in. Douglas-fir, 1-in. abura, obeche and English oak, and 1½-in. African mahogany. Several matched loads of each timber were dried at different temperatures and humidities.

The tests demonstrated that many species will tolerate considerably lower humidities than have hitherto been thought advisable. It is interesting that 1½-in. mahogany dried in 6 days at a temperature of 82° C. and a wet bulb depression of 12° C. (58% relative humidity) as compared with just over 3 days in superheated steam at 110° C. The rather longer time was offset to a certain extent by the smaller volume loss from collapse and distortion. [F. D. C. Tech. Bul. V. 5, No. 26]

Kollmann, F. Recent German-Swedish contributions to physics of lumber seasoning. *Transl. For. Prod. Lab., Can.* No. 82, 1954. pp. 18. Transl. from *Holz Roh- u Werkstoff* 12 (6), 1954 (213–23). [For. Abs. V. 16, No. 3]

Karlsen, O. Uptake of moisture by flooring during storage at building sites. *Medd. norsk tretekn. Inst.* No. 6 [1954].

A total of 288 floor boards were dried to about 9% m.c., cut to size and tied in bundles of 18; 15 of the bundles (1) were left completely unwrapped, (2) had the ends covered with asphalt sandwiched between layers of kraft paper, or (3) were wrapped with the ends left open, in asphalt sandwiched in kraft paper. In one single bundle, (4), stickers were placed between the boards, and it was left unwrapped. The bundles were distributed among 5 sites and stored in the open, under sheds (closed or open at one side) or in unfinished houses (brick or timber). Storage was for 6–10 weeks between 6 Oct. and 14 Dec. with weekly weighing. A record was kept of temperature and relative air humidity. Results (given in graphs and tables) show a very rapid recovery of m.c. in the material stored in the open, the m.c. of (1), (2) and (4) reaching 20–21% within 3 weeks. Recovery of m.c. of bundles stored in the houses and in sheds averaged 0.5–0.8% and 1.0% weekly, respectively. Recovery for (3) was very much less rapid, both in the open and indoors, than for the other classes. Conclusions are that softwood flooring should be kiln-dried to a m.c. representing equilibrium m.c. indoors and carefully protected during transport and storage at the site. [For. Abs. V. 16, No. 3]

Finishing

J. S. Hallows (Editor). Finishing handbook and directory 1955. Sawell Publications Ltd, 1955. 484 pp. (including 12 issues of *Product Finishing).*

Several changes have been made in the *Finishing Handbook* since the 1954 Edition. A new chapter on the chief types of paint includes sections on cellulose lacquers, cellulose thinners and synthetic resin-based finishes. There are brief notes on the chief properties of the different groups of finishes, such as alkyds and phenolics, and two tables showing the properties and applications of the same groups of materials.

The section on paint application methods has been expanded and now includes more information on dipping and spraying and also some information on flow coating and roller coating, and on catalyst, airless, steam, electrostatic and automatic spraying.

Revision of the Directory has led to a division of information into two categories 'equipment, plant and materials' and 'out-workers services'. This makes reference considerably easier, particularly as the first page of each category is marked by a thumb-indexing system. This system also facilitates reference to the list of addresses and the index, which have been difficult to find quickly in the earlier editions. Another difference in the Directory is the rearrangement of the equipment, plant and materials section into classifications corresponding with the sections in the *Handbook.* It is doubtful whether this will be of value to any but the most frequent users of the Directory, but the disadvantages may be offset by the inclusion of the individual headings in the general index. [F.D.C. Tech. Bul. V. 5, No. 26]

Preservation

Sandermann, W., Jonas, G.-Z., and Stockmann, H. Chemical nature of the fixation of preservative salts resistant to leaching, with and without As content. *Holz Roh- u. Werkstoff* 12 (8), 1954 (324–6).

The fixation of these preservatives consists in (1) reduction of the dichromate to chromous compounds, and (2) formation of sparingly soluble chromous salts. It was shown that the reduction is due almost exclusively to the phenolic groups of lignin. The sparingly soluble salts formed belong to the type Me^{I}_{2} $[CrF_5(H_2O)]$, where ME^{I} is a univalent metal. [For. Abs. V. 16, No. 3]

Machining

Rybalko, V. S. Increasing the durability of wood-cutting tools. *Derev. lesobim. Prom.* 3 (9), 1954 (3–8).

Describes the materials used in the U.S.S.R. for making cutting tools. Presents in graphs, tables, and diagrams the results of tests on cutters made of different steels: (1) the wear in μ plotted against length of cutting in m. (for Oak and Pine); (2) effect of hardness of the steel on wear; (3) outlines of the cutter edges (different steels) after cutting 1000 m. of Oak; (4) effect of wear of the edges on the quality of cut; and (5) power used for cutting

The preparation of abstracts from world literature in many languages is so highly specialized and costly that the Forest Products Research Society has no abstracting service of its own. For the abstracts in this issue of the JOURNAL the Society is indebted to the respective abstract journals indicated, from which they have been selected with the kind permission of the editors. Readers wishing information in addition to that given in these abstracts should consult the original articles referred to. Copies or additional information can not be supplied by FPRS or the abstract journal. The journals from which abstracts are published in this issue are as follows:

BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY, published monthly at Appleton, Wisconsin by the Institute of Paper Chemistry, subscription price $25 per year. This Bulletin publishes over 3,600 abstracts per year on subjects of interest to manufacturers of pulp, paper, fiber board and allied products.

CHEMICAL ABSTRACTS, published semimonthly by the American Chemical Society, Executive Office—1155 Sixteenth Street, NW, Washington 6, D. C., subscription price $60 per year plus postage. This abstract journal publishes many thousands of abstracts annually with broad coverage of world literature in the entire field of chemistry and allied subjects.

FORESTRY ABSTRACTS, published quarterly by Commonwealth Agricultural Bureaux, Farnham Royal, Slough, England, subscription price $8.40 per year. The abstracts are prepared by the Commonwealth Forestry Bureau, Oxford, England, and include a Forest Products and Utilization section. This section contains over 1,500 titles and abstracts per year from literature in some 30 languages, covers all aspects of forest utilization.

TECHNICAL BULLETIN OF THE FURNITURE DEVELOPMENT COUNCIL is published bimonthly by the Council at 11 Adelphi Terrace, London W. C. 2, England. The Technical Bulletin publishes hundreds of abstracts and reviews from world literature annually, relating to the various phases of the furniture manufacturing industry. Subscription price is $5 per year.

with dulled tools. It was found that wear decreases considerably when chips are directly removed by exhausters. The article ends with recommendations for improving output and quality of cut. [For. Abs. V. 16, No. 3]

Milling

A new sawing technique. *Holz-Zentralblatt,* Vol. 80 No. 136, 16 November 1954. p. 1602.

This new technique is claimed to improve the cutting qualities of a saw. It requires an increased top rake on the saw tooth and a reversed set, the high point of the tooth being bent towards the centre of the saw and not to the outside as in orthodox setting. This produces the effect of a double kerf as the tooth points remove about half the full kerf to a greater depth, and the low point of the tooth completes the full kerf width, thus each tooth removes two chips instead of one. The setting of the teeth, which is not greater than one-sixth the thickness of the blade, commences at the base of the tooth and not in the upper third only. [F.D.C. Tech. Bul. V. 5, No. 26]

Waste Utilization

Anon. Debarking and chipping at the L & M Lumber Company. *Paper Ind.* 37, no. 5: 438–9 (Aug., 1955).

A brief illustrated description of the wood-waste barking, chipping, handling, and transportation facilities at the company's sawmill in Willis, Texas is given. The chips are sent by railroad cars to local paper mills which will take all the chips the sawmills can supply. [Bul. Pap. Chem. V. 26, No. 1]

Doyle, J. A. Logging waste in Eastern Canada. *Bull. For Br. Can.* No. 115, 1954. pp. 24.

The first of a series of studies by the Forest Products Laboratories of Canada to determine the character and volume of usable wood left on logged areas in various parts of Canada. The principal sources of waste are: (1) high stumps, (2) long butts (the practice of cutting a bolt from the end of a log to eliminate defect), (3) large tops, and (4) uncut defective trees of merchantable diameter. It was found that (1) accounted for 2% of original merchantable volume of stands, (2) for 1.8%, (3) for 12.8% and (4) for 2.1%. [For. Abs. V. 16, No. 4]

Chemical Utilization

Stone, J. E. The rheology of cooked Wood. II. Effect of temperature. *Tappi* 38, no. 8: 452–9 (Aug., 1955).

A study has been made of the effect of temperature on load to failure, percentage deformation at failure, and work to failure of yellow birch subjected to a radial shear. The wood was heated oven dry in oil or water swollen in sodium bicarbonate solution. The temperature range was room to 205° C. for oil, and room to 185° for the aqueous system. Specimens were tested at the elevated temperatures and also after cooling. Photomicrographs were obtained of the plane of failure. Results indicate that for ovendry wood in oil no strength is lost by heating and cooling, but when tested hot, there is some strength lost at the higher temperatures. The percentage deformation at failure increases with temperature as does the work to failure. In the aqueous system there is a very considerable loss in strength over the temperature range 80–120°. The percentage deformation at failure shows a maximum at 90° and a minimum at 140°. The work to failure decreases with increasing temperature. The microscopic study shows wood in oil at room temperature to fail across a double cell wall from lumen to lumen; in oil at 205° the plane of failure tends to follow around cell walls between the cells; in the aqueous system at 25° there is much fibrillation of the outer surfaces of separated cells; at 120° in the aqueous system there is a much cleaner break but still some fibrillation; at 185° all the cells collapse under the shear force. [Bul. Pap. Chem. V. 26, No. 1]

Glab, W. T. (Carr, Adams & Collier Co.) A molded lignocellulose. U. S. Patent 2, 708, 637, May 17, 1955.

A finely divided lignocellulose and a finely divided strong alkali are heated under pressure to form a molded product. The lignocellulose is —20 mesh in size and contains less than 30 per cent moisture. The alkali is less than 30 per cent by weight of the lignocellulose, —100 mesh in size and may be an oxide or hydroxide of the alk. earth metals or a hydroxide of the alkali metals. A mixture of the lignocellulose and the alkali is preheated at 400–600° F for less than 15 minutes. The vapors are vented, and the mixture is then molded at 400–600° F. and at pressure of 50–5000 psi for less than 30 minutes. [Chem. Abs. V. 49, No. 16.]

Particle Board

Fehn, H. Chipboards: a preliminary review and a survey of different European manufacturing methods. *Utredn. Norsk tretekn. Inst.* No. 9, [1954.] pp. 29.

Discusses general points in chipboard manufacture and describes in more detail the products and the processes used by: Ji-Te Fabrikker and Sveahus (Bremmer boards), Sweden; Fahrni Institute (Novopan), Interwood, and Fibrexa (Tavapan), Switzerland; P. Harder (Curvi-Board), Lichtenstein; Ferd. Schenk (Duroplan and Struktoplan), Rohenstroht (Wirus), O. Kreibaum (Okal), Nord Deutsche Homogenholz, Rottmann (Rowi) and Fibroplast, Germany; Vere Engineering Co. (Bartrev), Airscrew Co. and Jicwood Ltd. (Weyroc) and British Plimber Ltd. (Plimberite), England; and Quenild (Novotex), Norway. There is a summary table showing the raw material, capacity, capital investment, and weight and uses of boards for each firm. [For. Abs. V. 16, No. 3]

Hardboard

Helge, K., and Krogstad, K. Research at the Paper Industry Research Institute on the manufacture of hard wallboard and the determination of its properties. *Norsk Skogind.* 9 (1), 1955 (12–6).

Deals mainly with the causes of variation in thickness of boards and its effect on their properties. [For. Abs. V. 16, No. 3]

Farmer, R. H., and Packman, D. F. The production of hardboard from tropical timbers. I. Kempas *(Koompassia malaccensis). Colonial Plant and Animal Products* (London) 4: 293–309 (1954).

Standard hardboard and super hardboard, according to British Standard 1142: 1953, were made from Malayan timber, particularly kempas (I) by a modified neutral sulfite process. Chips of I were cooked at 180° for 0.5 hour with liquor containing Na_2SO_3 equal to 3.5 per cent weight of dry wood. Defibration was performed with a lab. model disk mill. A pulp sample equivalent to 200 g. dry weight was used for each sheet. Sheets were formed first at room temperature and 200 or 500 psi, then were pressed into 1/8-inch boards (II) in the hot press on 20-mesh wire 10 minutes at 180°. Sizing with wax or bitumen emulsion increased H_2O resistance but reduced the strength of II. Spraying II with linseed oil before hot air treatment resulted in adequate strength and lower H_2O absorption. [Chem Abs. V. 49, No. 19]

Properties

Kelsey, Kathleen E. The apparent density of wood substance. *Australian J. Appl. Sci.* 6, no. 2: 190–6 (June, 1955).

The apparent density of dry *Pinus radiata* D. Don wood flour has been determined in water and in a number of organic displacement liquids. The effect of molecular weight appears to be significant only within a homologous series and for nonswelling liquids. A positive correlation has been observed between the apparent density and the external swelling produced by the displacement liquid in matched samples of *P. radiata.* The results indicate that differences in the degree of penetration by the displacement liquid are not the sole cause of the observed variations in apparent density, but that the forces of interaction between the wood and the liquid also play an important part. [Bul. Pap. Chem. V. 25, No. 12]

Noren, B. Relation between compressive strength and rate of deformation in testing Swedish Fir [*Pinus sylvestris*]. *Bull. Amer. Soc. Test. Mat.* No. 202, 1954 (43–50).

In his tests on the effect of the rate of loading on the strength properties of wood, Perem [cf. *For. Abstr.* 12 (No. 374)] used for the most part a constant rate of loading. In this investigation a constant rate of deformation (dR/R) is used, and the strength property investigated is compression ‖. The selection of test pieces and the apparatus used are described and illustrated. The tabulated and graphed results show that the compressive strength ‖ varies as the logarithm of the rate of deformation. [For. Abs. V. 16, No. 3]

Timbers of South East Asia. Timber Development Association Ltd., January 1955, 91 pp.

This booklet gives details of the strength, durability, working qualities, seasoning properties and uses, together with the botanical and common names of 45 timbers exported to Britain from countries in South East Asia. The timbers described are not necessarily available at the present time, and a note on 'supplies' is included under each one. The booklet is a companion to 'Timbers of West Africa' and 'Timbers of South America'. [F. D. C. Tech. Bul. V. 5, No. 28]

Noise Abatement

Meiter, E. G. Stop that noise. *Paper Mill News* 78, no. 34: 8, 10, 12 (Aug. 20, 1955); *Southern Pulp Paper Mfr.* 18, no. 9: 78, 80, 82 (Sept., 1955).

The author discusses basic information on the problem of noise in industry, including a definition; unit and method of measurement; determination of limits on the basis of intensity and frequency levels; detection and control of noise hazards; the audiometer; engineering control measures—control of noise at the source, substitution of a less noisy operation, isolation or segregation from noise, use of resilient mountings, and use of sound-absorptive materials; and protection to the ear. [Bul. Pap. Chem. V. 26, No. 2]

FPRS Welcomes The Upson Co. As Newest Supporting Member

The Upson Company, Lockport, N. Y., has become a FPRS Company Supporting Member, joining more than 100 firms helping promote the scientific progress of the industry.

W. P. ERICKS

Dr. W. P. Ericks, Director of Research, is the firm's designated representative to the Society. He also is Vice-President and Director of Research of The Upson Chemical Corp., a subsidiary of The Upson Co.

W. H. Upson, Jr., is President and James J. Upson is Executive Vice-President of the Lockport company. The world's largest manufacturer of laminated wood fiber panels under one roof, the company also has two other subsidiaries, Tuco Work Shops, Inc., and Beaverboard Co., Inc.

Now in its 46th year, the firm produces panels for dry wall construction, including special panels for interior walls and ceilings, sheathing for exteriors, and a new primed siding product. Upson also makes a primed panel used for soffits, carports, porch ceilings, and garages.

The Upson Company produces panels for dry wall construction at Lockport, N. Y. plant.

Dr. Ericks was graduated in 1927 from Pratt Institute, Brooklyn, with a degree in chemical engineering. He received his M.A. in 1933 and Ph.D. in 1935 from the University of Buffalo, where he specialized in chemistry. In 1942 Dr. Ericks became Director of Research of The Upson Co., having previously been associated with Charles Pfizer & Co., Brooklyn; National Aniline Division, Allied Chemical & Dye Corp., Buffalo; and American Cyanamid Co., Stamford, Conn.

Among his research discoveries is a process of dimensional stabilization of cellulose fiber materials such as paper made from various types of pulp. This process and a number of other processes and products in other fields are covered by more than 30 U. S. patents held by Dr. Ericks.

Meet FPRS 100 Company Supporting Members

ALABAMA
W. T. Smith Lumber Co., Chapman

ARKANSAS
The Crossett Co., Crossett
Dierks Forests, Inc., Mountain Pine
Southern Lumber Co., Warren

CALIFORNIA
California Redwood Association, San Francisco
L. J. Carr & Co., Sacramento
Crane Mills, Corning
Ivory Pine Co., Dinuba
National Wood Treating Corp., Oroville
Philadelphia Quartz Co. of California, Berkeley
Scott Lumber Co., Inc., Burney
Tarter, Webster & Johnson, Stockton
E. K. Wood Lumber Co., San Francisco

GEORGIA
Southern Wood Preserving Co., Atlanta

IDAHO
Boise Payette Lumber Co., Boise
Ohio Match Co., Coeur d'Alene

ILLINOIS
The Dean Company, Chicago
General Electric, Ill. Cabinet Plant, Rockford
Greenlee Tool Co., Rockford
Edward Hines Lumber Co., Chicago
Illinois Interior Finish Co., Chicago
Johnson & Carlson, Chicago
Masonite Corp., Chicago
Mattison Machine Works, Rockford
Sherwin-Williams Co., Chicago
Steger Furniture Mfg. Co., Steger

INDIANA
The Dunbar Furniture Mfg. Co., Berne
National Homes Corp., Lafayette
The Wood-Worker & Veneers and Plywood, Indianapolis

IOWA
Curtis Co. Inc., Clinton

MARYLAND
J. I. Wells, Salisbury

MASSACHUSETTS
Draper Corp., Hopedale
Heywood-Wakefield Co., Gardner
A. G. Spalding & Bros., Inc., Chicopee

MICHIGAN
Baker Furniture, Inc., Grand Rapids
The Dow Chemical Co., Midland
Everett Piano Co., South Haven

MINNESOTA
Mereen-Johnson Machine Co., Minneapolis
Rilco Laminated Products, Inc., St. Paul
Wabash Screen Door Co., Minneapolis
Winton Lumber Co., Minneapolis

MISSOURI
Monsanto Chemical Co., St. Louis

MONTANA
Intermountain Lumber Co., Missoula

NEVADA
Vaughn Millwork Co., Reno

NEW YORK
American Defibrator, Inc., New York
Behr-Manning Corp., Troy, N. Y.
Borden Co., New York
Peter Cooper Corps., Gowanda
Georgia Pacific Plywood Co., New York
Oval Wood Dish Corp., Tupper Lake
Reichhold Chemicals, Inc., White Plains
U. S. Industries, Inc., New York
United States Plywood Corp., New York
The Upson Co., Lockport

NORTH CAROLINA
Deluxe Saw & Tool Company, High Point

OHIO
The Baldwin Piano Co., Cincinnati
Coe Manufacturing Company, Painesville
The Kirk & Blum Mfg. Co., Cincinnati
Moraine Box Company, Dayton

OREGON
Cascades Plywood Corporation, Portland
Forest Fiber Products Co., Forest Grove
Mater Engineering, Corvallis
J. Neils Lumber Co., Portland
Oregon Lumber Co., Baker
West Coast Lumberman's Assn., Portland

PENNSYLVANIA
Blaw-Knox Company, Pittsburgh
Koppers Company, Inc., Pittsburgh
Perkins Glue Co., Lansdale
United States Steel Homes, Inc., Harrisburg
Wood Metals Industries, Inc., Kreamer

SOUTH CAROLINA
Lightsey Brothers, Miley

TENNESSEE
E. L. Bruce Co., Memphis
Chapman Chemical Company, Memphis
Memphis Hardwood Flooring Co., Memphis
Nickey Bros., Inc., Memphis

TEXAS
Wm. Cameron & Co., Inc., Waco
Kirby Lumber Corporation, Houston
Wynnewood Products Co., Jacksonville

VERMONT
Beecher Falls Mfg. Corp., Beecher Falls
Fyles & Rice Co., Inc., Bethel

WASHINGTON
American Marietta Co., Seattle
Biles Coleman Lumber Co., Omak
Cascade Lumber Co., Yakima
Columbia Plywood Co., Inc., Seattle
Deer Park Pine Industry, Inc., Deer Park
Diamond Match Co., Spokane
Douglas Fir Plywood Association, Tacoma
The Long-Bell Lumber Co., Longview
Simpson Logging Co., Shelton
Sumner Iron Works, Everett
Weyerhaeuser Timber Co., Tacoma

WISCONSIN
Harnischfeger Corp., Port Washington
Marathon Corp., Rothschild
Mosinee Paper Mills Co., Mosinee
D. J. Murray Mfg. Co., Wausau
Paine Lumber Co., Oshkosh

ALASKA
Ketchikan Spruce Mills, Ketchikan

CANADA
B. C. Forest Products, Ltd., Vancouver
British Columbia Lbr. Mfrs. Assn., Vancouver
Canadian Forest Products Limited, New Westminster, B. C.
Dominion Electrohome Industries, Ltd., Kitchener, Ont.
Knight Mfg. & Lbr. Co. Ltd., Meaford, Ont.
MacMillan & Bloedel Ltd., Nanaimo, B. C.
A. S. Nicholson & Son, Ltd., Burlington, Ont.

Abstracts of Papers, FPRS Tenth National Meeting

Here's Your Preview of Papers to Be Presented at National Meeting in Asheville, June 4–7

R. J. HADER

A. E. WYLIE

Session I—Quality Control in Wood Products

SOME EXPERIMENTAL DESIGNS APPLICABLE TO PROBLEMS WITH WOOD. Robert J. Hader, N. C. State College, Raleigh, N. C.

Precision of experiments to compare two or more treatments may often be dramtically improved by use of ingenious schemes for allocating the experimental material so as to balance out extraneous components of variation. Such schemes, called experimental designs, have long been used in agrobiological experimentation and are now being found extremely useful in industrial research.

Experimental results frequently show disturbingly large random variation, even under the most carefully controlled conditions. Often this variation is due in large measure to inherent differences in the raw material used in the experimentation. In an experiment to compare two or more treatments, the most simple design is to randomly assign the available experimental units (i.e. raw material, etc.) equally to the several treatments. By increasing the number of units (tests) per treatment the inherent random variations will tend to average out. If, however, the experimental material can be arranged into smaller groups so that "within group" inherent variation is appreciably less than "between group" variation, then the treatments may be assigned randomly *within each group* and thus compared unaffected by the between group variation. This is the important principle of "blocking".

If each group is large enough to accommodate all treatments, the arrangement is called a "randomized complete block design". If only part of the treatments can go into each block, the design is called an "incomplete block design". An example of the use of the latter arrangement is discussed in detail in connection with an experiment to investigate the influence of water and air temperature on the standard cyclic exposure test for plywood delamination.

MANAGEMENT POSSIBILITIES WITH QUALITY CONTROL METHODS. Charles A. Bicking, Office, Chief of Ordnance, Washington, D. C.

At the management level, decisions are usually based on tabular or graphical presentation of data. Because quality control provides a quick and efficient way of presenting evidence on which decisions may be based, it has caught the eye of top management. Not only in connection with production, but also in connection with purely administrative problems, many examples of successful use of quality control methods are available.

Problems as varied as cost control, employee performance, scheduling of operations, and safety improvement have been studied through control charts. It is difficult to think of any activity of management that cannot be improved by some application of quality control techniques.

ACCEPTANCE SAMPLING OF VENEER USING THE LOT-PLOT PLAN. Aubrey E. Wylie, State U. of New York College of Forestry, Syracuse; and Ward Hitchings, West Quincy, Mass.

Acceptance sampling has two major objectives. One is to obtain facts as a basis for decisions regarding acceptance of lots purchased. The other is to convert these facts into corrective manufacturing adjustments. The lot-plot plan has served a wide variety of industries effectively in this work.

The lot-plot employs a frequency histogram in an analysis of quality on a lot basis. The information provided a supplier is designed to encourage that producer to manufacture and ship a product that consistently meets specifications. The method is based on sampling a variable rather than an attribute. The plan makes use of a frequency distribution in obtaining an average and three standard deviation limits. A visual comparison can be made between the frequency distribution and a normal curve.

The paper gives the procedure involved in developing a lot-plot. Examples of applications are given for moisture content and thickness of veneer.

The results of using the lot-plot for sampling veneer characteristics clearly indicate that this relatively simple technique is a valuable management tool that is readily understood. It seems reasonable to believe that the lot-plot could be used to great advantage by wood processing plants on other products.

STATISTICAL SAMPLING PROVES TO BE EFFICIENT AND ACCURATE IN RECEIVING INSPECTION. L. O. Reed and R. T. White, Brunswick-Balke-Collender Co., Marion, Va.

Statistical sampling has been used at The Brunswick-Balke-Collender Company, Marion, Va., for more than two years in the receiving inspection of veneer. This form of sampling, when used in conjunction with other fundamental practices associated with good inspection, has proved to be very successful in maintaining quality at a minimum cost. Statistical sampling removes the guesswork often allied with spot checking and cuts cost by virtually eliminating 100 per cent inspection.

L. O. REED

A. F. VERRALL

R. J. KOWAL

W. L. MEEK

Session II—Preservation of Wood Materials Used in Building

HOW TO PREVENT FUNGUS DAMAGE TO WOOD STRUCTURES. Arthur F. Verrall, Southern Forest Experiment Station, Gulfport, Miss.

Decay of wood in buildings usually indicates misuse rather than nonsuitability. Fungus attack is mainly a problem of moisture relationships; experience and research have shown how moisture accumulations can be prevented, permitting the safe use of wood for most building needs. Decay can be kept to an insignificant level without appreciable added cost. The use of well-manufactured and properly-handled lumber along with construction features to minimize moisture accumulations usually affords adequate protection. For specific uses of high decay hazard, a naturally decay resistant wood or one with proper preservative treatment is necessary. The judicious use of preservatives for some points of moderate decay hazard is worthwhile added insurance.

HOW TO PREVENT INSECT DAMAGE TO WOOD STRUCTURES. R. J. Kowal, Southeastern Forest Experiment Station, Asheville, N. C.

Insect damage to wood and related cellulose building material in storage and in structures amounts to millions of dollars annually. Most of it is preventable. Subterranean termites and powder-post beetles cause the major loss; but many other insect species, while individually inconspicuous, in the aggregate do a substantial amount of damage. The paper presents the various types of insect problems and the situations under which they develop, describes the insect's activities and the damage they cause, and suggests methods of preventing insect attack.

USE OF PRESERVATIVES IN BOARD PRODUCTS. Wayne L. Meek, Minnesota and Ontario Paper Co., International Falls, Minn.

Outlines the present position and problems of the fiberboard industry with respect to preservative treatment. In developing this subject, three questions are raised and partially answered. They are:

1. Has the ideal chemical, both from the effective and economical point of view, been discovered?

2. What is the most effective means of introducing a chemical preservative into fiberboard?

3. Is there sufficient proof of the desirable level of treatment necessary to assure protection under actual use conditions?

R. B. PUTNAM

R. R. BOTTOMS

R. G. VANALLEN

M. J. RHUDE

W. J. FINNORN

H. B. McKEAN

HOW AND WHAT TO SPECIFY FOR THE PRESERVATIVE TREATMENT OF WOOD TO BE USED IN BUILDINGS. R. B. Putnam, Wood Preserving Div., Koppers Co., Inc., Pittsburgh, Pa.

Discusses wood preserving compounds and processes of application as related to wood-destroying agencies under various types of exposure in different types of buildings. Uses of preserved wood in houses, light commercial, and heavy industrial construction will be described. Included will be specifications currently applied, standards of technical organizations, and typical requirements of industrial engineers for treated wood elements in buildings.

A NEW METHOD FOR LONG-TERM PRESERVATION OF WOOD BY CHEMICAL MODIFICATION. E. Abrams, Southern Research Institute, Birmingham, Ala.; F. G. W. Smith and S. M. Miller, Marine Laboratory, U. of Miami; and R. R. Bottoms, National Cylinder Gas Co., Crestwood, Ky.

A comparative discussion and detailed description is given of a new process for wood preservation whereby a permanently bonded copper-cellulose complex is formed. The paper includes a review of copper treatments now in use. The description contains tabulated comparison results of soil and marine exposure tests, with a discussion of the test methods.

A NEW METHOD FOR APPLYING PENTACHLOROPHENOL TO WOOD IN PLACE. R. G. VanAllen, Wood Treating Chemicals Co., St. Louis, Mo.

Describes a new form of Penta petroleum solution which is based on a thickened emulsion. When applied to wood in existing structures, etc., this solution functions as a reservoir, gradually breaking down at a rate in keeping with the adsorption of the wood. Various applications are outlined and results of penetration studies covering the in-line treatment of utility poles as well as 2 x 8 structural timber are included to demonstrate performance.

Session V—Keeping Abreast in Wood Gluing

PERFORMANCE OF UREA-RESIN GLUES AT ELEVATED TEMPERATURES. R. F. Blomquist and W. Z. Olson, U. S. Forest Products Laboratory, Madison, Wis.

Urea-resin glues have previously been shown to be adequate for service at normal room temperatures but to lose a high proportion of their initial strength upon continuous or intermittent exposure at 158° F., a temperature of interest in earlier work with wood aircraft. There are a number of current applications for glues in housing and other applications where service temperatures somewhere between normal room temperature and 158° F. are typical. The present study was therefore undertaken to study the performance of glue joints of several types of urea-resin glue formulations in continuous exposure at 80°, 120°, 140° and 158° F. Eleven glues were studied, including powdered, high-, and low-solids liquid resins, with and without wheat flour extender, and cured both in hot presses and at room temperature. Data are reported for the first three years of exposure. Tests are being continued for two additional years.

Session VI—Keeping Abreast in Wood Gluing

PRODUCTION AND QUALITY CONTROL OF LAMINATED TIMBERS. M. J. Rhude, Unit Structures, Inc., Peshtigo, Wis.

The real secret of success of the quality control department lies in defect prevention, by feeding information back into the production department as soon as possible, so that faulty production may be stopped.

Quality control functions in the following categories of laminated timber fabrication:

1. Surveillance of quality throughout all phases of fabrication, from receipt of materials to shipment of the finished member.
2. Sampling of the product for testing and acceptance or rejection.
3. Assistance in establishment of proper production procedures and training of production personnel in quality practices.
4. Liaison between production and engineering departments.
5. Analysis of service reports and action as a trouble-shooting service.

SAFE BENDING RADII FOR CURVED LAMINATES. W. J. Finnorn, Timber Engineering Co., Washington, D. C.; and A. Rapavi, Bureau of Ships, Washington, D. C.

An investigation sponsored by the Bureau of Ships is being conducted by the Timber Engineering Company to determine minimum safe radii of curvature for woods commonly used in the Navy's wood ship building program. Empirical formulae for practical, safe bending radii have been developed for African mahogany, Douglas-fir, and white oak. The relative bending properties of these species and of Philippine mahogany, Honduras mahogany, and preservative-treated red oak have been determined.

R. F. BLOMQUIST

W. Z. OLSON

PRODUCTION LAMINATING OF 2 x 4'S. H. B. McKean, Potlatch Forests, Inc., Lewiston, Idaho.

A method for rapid laminating of lumber has been developed which reduces the time under pressure for this class of product from an average of four hours to a matter of seconds. Typical exterior-type adhesive bonds are produced and the process can utilize the less expensive phenol resins as well as the resorcinol-phenol combinations.

Although heat is utilized as the accelerating influence, high frequency heat sources are not necessary. The basic principle involves storage of heat on the surfaces of the lumber to be laminated, then applying the adhesive, and finally, pressure.

Preheating one contacting surface on a hot plate at 350° F. for 5 minutes while spreading adhesive on the other contacting surface provides adequate heat to cure resorcinol-phenol adhesives in 30 to 60 seconds. In order to provide sufficient heat to cure phenol resins in the same interval of time, both contacting surfaces had to be preheated. Contrary to expectation, adhesive spread on these hot surfaces suffered no observable ill effect when pressure was applied within 4 seconds.

A pilot plant is now in operation at Potlatch Forests, Inc., Lewiston, Idaho, manufacturing laminated 2 X 4's from lower grades of 1 X 4's. The economics of this method of hot gluing indicate an expansion of gluing techniques in solving the problems of the lumber industry. Application of the method to such products as laminated beams for home building, with marked reduction in costs, is an imminent possibility. Press times for large beams would be the same as for two-member assemblies.

Session VIII—Chemicals from Lignin, Hemicellulose, and Other By-Products

THE NATURE OF ASPEN LIGNIN. Irwin A. Pearl, Institute of Paper Chemistry, Appleton, Wis.

During the past several decades, considerable attention has been given to the chemical utilization of the lignin wastes of the sulfite pulping industry, and the literature is abundant with suggestions for the recovery of valuable chemical by-products. Among the several factors responsible for much of the research in this field have been the need for conservation in order to meet expanding requirements for our raw materials, the urge for more economical production in the face of higher operating costs, and the pressure for abatement of effluents that are regarded as constituting a public nuisance.

Substantially all research on spent sulfite liquor has been performed on liquors

I. A. PEARL

A. S. GREGORY

from the pulping of coniferous woods such as spruce or hemlock, woods which traditionally have been associated with sulfite pulps. Within the last ten years, the picture in the Lake States has changed. The shortage of native spruce, the high freight rates on imported spruce, and the threatened embargo on spruce by the Province of Ontario, together with the large price differential, have led many of the sulfite mills in this area to the pulping of the two indigenous aspens—quaking aspen *(Populus tremuloides)* and bigtooth aspen *(Populus grandidentata)*.

Utilization of aspen spent sulfite liquor presented new problems. Utilization schemes evolved over the years for coniferous liquors were found to be unamenable to aspen liquors. In fact, most of the conventional methods for the analysis of and separation of components from spent sulfite liquors gave misleading results when applied to aspen liquors. These conditions led to the initiation of a fundamental study on the nature of aspen spent sulfite liquor and of aspenwood with particular emphasis on the lignin content of both.

Experiments over the past two years on aspen spent sulfite liquor, aspen "isolated native lignin," completely extracted aspenwood, and aspenwood extractives have indicated that the nature of the lignin of aspen does not agree with traditional concepts of lignin—even hardwood lignin. This paper discusses the nature of aspen lignin in the light of the above experiments.

ESTERIFICATION OF WOOD. 1. EFFECT OF SWELLING AGENTS AND CATALYSTS ON ACETYLATIONS. L. P. Clermont and F. Bender, Forest Products Laboratories of Canada, Ottawa, Ont.

Work done by J. C. Thomas (J.A.C.S. 75, P. 5346, 1953) has shown that a rapid acetylation of cellulose under comparatively mild conditions can be achieved by a pre-treatment consisting of impregnation with an aqueous solution containing 38% urea and 2% ammonium sulphate, and drying the impregnated material. This treatment has been applied to wood in the form of sawdust (extracted black spruce, 20–40 mesh). By this method it has been found possible to acetylate wood fairly rapidly and under comparatively mild conditions, i.e., temperatures as low as 85° C. and reaction times of approximately 1 hour. It might be possible to even further lower the reaction temperatures.

The amounts of urea required for maximum acetylation were in the order of 20 per cent (based on the dry weight of the wood). Further increase in urea content did not lead to an appreciable increase in acetyl content. The moisture content of the impregnated material to be acetylated was not found to be critical. Moisture contents up to 100 per cent did not appreciably reduce the acetyl content of the treated material.

Sawdust swollen in dimethylformamide was also acetylated with acetic anhydride. Ammonium sulphate was used as the catalyst. This method of acetylation might become of special significance since no water is involved.

Acetylation of veneers, e.g., 1/8-inch thick birch, spruce, maple veneers, by the method of Thomas leads to materials with high acetyl contents, and with a correspondingly reduced swelling in water. Some of the original strength of the wood is lost in the treatment. The loss, however, is much smaller than in conventional acetylations and might not interfere with the usefulness of the products.

Some studies were undertaken to determine the mechanism of the acetylations. Since it has been proposed by Thomas that acetyl-urea might be the intermediary compound responsible for the acetylation of cellulose, attempts have been made to use this material for acetylations of wood. These attempts failed to produce acetylated materials; it is therefore concluded that acetyl-ureas are not responsible for acetylations obtained under the prevailing conditions.

QUERCETIN FROM DOUGLAS-FIR BARK. A. S. Gregory, D. L. Brink, L. E. Dowd, and A. S. Ryan, Weyerhaeuser Timber Co., Longview, Wash.

Water extraction of Douglas-fir bark from water-borne logs gives extracts with low Dihydroquercetin (DHQ) content. The presence of large percentages of non-DHQ material makes crystallization of the DHQ very difficult. A low-cost oxidation process has been developed which converts the DHQ in the extract to Quercetin. This product is much less soluble and readily recovered. The effects of the independent process variables on the reaction, the kinetics of the reaction, and possible reaction mechanism are discussed.

Session X—More Complete Utilization in Logging and Milling

CHIP YIELD BY LOG GRADE AND SIZE IN THE CALIFORNIA PINE AND FIR REGION. N. T. Shelton, Diamond Match Co., Chico, Calif.

The planning of an integrated forest products industry which utilizes all of the timber and wood residual resources requires a means of predetermining a materials balance on the basis of the volume in cubic feet developed in the form of lumber, bark, sawdust, chippable wood, and shavings. The type and design of the lumber manufacturing and wood by-products operations are dependent on a reasonable estimate of the quantity of wood residuals that will be produced in the form of lumber, chips, and wood fuel as affected by the log size, specie, log grade, and sawing methods.

F. BENDER

L. P. CLERMONT

N. T. SHELTON

W. E. McCRAW

This paper is a case history which describes: (1) the given conditions in regard to the log volume, specie, grade, and number of logs by diameter ranging in size from 6 to 72 inches in diameter; (2) the procedure used in a sawmill study to determine the materials balance; and (3) a tabulation of the results.

The final results are shown in terms of the cubic feet produced per log by log diameter so that the data can be applied to other operations where the number of logs of each diameter to be sawn is known and the method of sawing is similar. The same data is given in terms of cubic feet per M net log scale by bulk and solid wood density and in terms of wood units of 200 cu. ft. Although this discussion primarily is concerned with the green end of the operation, data on the wood residual produced by a surfacing and moulding operation will be included.

THE FUTURE OF RUBBER-TIRED TRACTORS IN LOGGING. W. E. McCraw, Caterpillar Tractor Co., Peoria, Ill.

The use of rubber-tired tractors in logging is a comparatively new development. All models being offered by various manufacturers should be considered as strictly experimental designs, with a considerable range in horsepower and weight. However, test experience to date has shown that the use of rubber-tired tractors in conjunction with conventional track-type tractors will have a tremendous influence on future logging methods.

The fact that more timber is being logged in more remote areas has brought truck road building costs under sharper scrutiny by woods management. The use of rubber-tired tractors can offset this increase in costs by their ability to yard out much larger distances, thereby reducing the necessity of building truck roads to the stump.

LOGGING INJURY IN CENTRAL STATES UPLAND HARDWOODS. D. E. Herrick, Central States Forest Experiment Station, Carbondale, Ill.

In any woodland management system involving selective cutting, some of the trees left in the residual stand will be unavoidably injured or destroyed by the skidding operation. Efficient forest managers constantly strive to minimize this loss but are hampered in their effort by a lack of information on the influence of various types of equipment and methods of application. One part of a study recently conducted in the Shawnee Hills section of southern Illinois was designed to develop such information for tractor logging. This study involved ground-, pan-, and sulky-skidding of log-length loads with three sizes of crawler-type tractors, and sulky-skidding of tree-length loads with two sizes of tractors.

Results of the study indicate that:

1. For both log-length and tree-length skidding, and regardless of the equipment

D. E. HERRICK

B. ZOBEL

combination used, skidding injury occurs chiefly on sapling-sized trees. Few pole- and sawtimber-sized trees need be injured.

2. Bunching with a sulky or an arch will result in the least amount of disturbed area and the smallest number of injured trees per thousand board feet bunched.

3. There is no appreciable difference between log-length and tree-length logging with respect to their influence upon the over-all level of stocking of the residual stand.

GENETIC, GROWTH, AND ENVIRONMENTAL FACTORS AFFECTING SPECIFIC GRAVITY OF LOBLOLLY PINE. Bruce Zobel, Texas Forest Service, Lufkin, Texas.

The Texas Forest Service has underway an intensive program of forest genetics research. One of the main fields of study is that of the genetics of wood properties. This paper lists results to date of studies on wood specific gravity.

Final results from the genetic tests are not yet available, but indications obtained are reported. It was found that the commonly considered specific gravity determiners such as growth rate, age, site, etc., taken singly or in combination, contributed only a small proportion to observed specific gravity variations. A relationship between specific gravity of juvenile and mature wood is also reported, with its value and application briefly discussed.

DEVELOPMENT OF AN AUTOMATIC SAWMILL CARRIAGE FEED. M. H. Mater, Mater Engineering, Corvallis, Ore.

This paper covers the initial phase of a three-part research and development program undertaken to develop an automatic system of controlling the sawing speed. Research to determine the practicability of certain control indicators is described; bandmill motor amperage requirements, saw deflection, and strain arm movement are three of the indicators of sawing speed which were investigated.

The final objective of this program is to develop a control system to eliminate normal sawyer error in determining sawing speed. For this purpose, the resistance of the saw to the forward movement of the wood is used to determine an optimum sawing speed. This paper reports the basic research required to determine the curve of amperage demand, with relation to time-in-the-cut.

The effect of knots on the various possible indicators was studied; the effect of the upper saw guide position in relation to the resultant dimensional stability was also investigated.

Criteria of dimensional variations and smoothness were set up to determine optimum sawing speeds.

A curve of amperage requirements vs. time was finally developed which will be used to develop the sawing speed control device which will be tested in Phase II of this program.

Session XII—How to Select A Better Finish for Furniture

DISCOLORATION OF FURNITURE FINISHES. D. G. Lubeck, Hammond Organ Co., Chicago, Ill.

The discoloration of furniture finishes involves a pattern of predictable behaviors that can be prevented or controlled by a proper selection of materials and an understanding of the processes of discoloration.

Three stratas that must be considered with regard to discoloration are: the wood substrates, the finishing materials applied to the substrates, and the possible contaminates, such as oil, which come in contact with the top-coat films.

Panel preparation and the equipment used to simulate and accelerate in-use conditions that cause discoloration are very important. Discoloration is often a combination of many factors and a complete understanding of each of the above strates as well as their interrelated behavior must be understood before a complete evaluation can be made.

This paper describes a test designed to study these variables. The involved factors are discussed in the following order:

1. Specimen Preparation. With sample preparation, it is important that each variable be isolated so that the individual behavior of a material can be determined, as well as its contribution to the complete system.

2. Methods of Exposure. Seven exposure conditions are discussed, ranging from diffuse sunlight to direct Florida sunlight.

3. Effects of Exposure to Ultraviolet Radiation. A description is given of the effects of ultraviolet radiation on all factors tested —wood, stains, toners, fillers, sealers, lacquers, and lacquers with additives and contaminants.

4. Recommended Procedure for Discoloration Tests. Gives brief description of tests to be made to predict discoloration behaviors.

SYNTHETICS VS. NITRO-CELLULOSE LACQUERS. W. M. Beaver, American-Marietta Co., High Point, N. C.

Nitro-cellulose lacquers and synthetic alkyd-urea varnishes are the most important topcoat materials in the field of furniture finishing today. Lacquer products are well known to nearly everyone in the business and their properties are well established. Synthetics, although on the market for about 15 years, are not as well understood and in addition have undergone drastic improvements since their first appearance in the industry.

Chemically the two topcoats are completely different. Lacquers are solutions of nitrocellulose, resins, and plasticizers which dry essentially by evaporation of

M. H. MATER

D. G. LUBECK

W. M. BEAVER

J. D. EVANS

the solvent. Synthetics are combinations of alkyd and urea-formaldehyde resins with modifiers which dry or cure by a complex heat and catalyst induced oxidation-polymerization mechanism. As would be expected, these compositional differences account for many variations in the ultimate properties of the films of the two materials when applied to a wooden substrate.

There are many variations possible in the formulation of lacquers and synthetics and naturally there are top and low quality products in both categories. Both can be tailor-made for optimum performance in specific situations and it must be left to the user to decide which will best serve his requirements.

Session XIII—Packaging and Shipment of Furniture

FIBREBOARD FURNITURE PACKAGES. J. D. Evans, The Mengel Co., Winston-Salem, N. C.

History and development of corrugated fibreboard packages for furniture will be traced. The corrugated box industry will be discussed with reference to paper and board constructions, printing, and its relationship to the furniture industry. Furniture packages of corrugated fibreboard will be described and boxes, clearance forms, and packing pads will be demonstrated.

Predetermination of furniture package durability by testing will be discussed. Various testing methods covered will include: Mullen test, vibration test, drop test, conbur incline impact test, G. E. puncture test, and compression test.

THE FURNITURE MANUFACTURER'S VIEWPOINT ON PROTECTION OF FURNITURE FOR SHIPMENT. Sam W. Freeman, Drexel Furniture Co., Drexel, N. C.

The furniture packaging operation has been revolutionized during the past decade, in terms of materials as well as processes. Packaging techniques and processes have improved concurrently with the general improvement in quality of furniture. The progressive mid-century furniture manufacturer employs furniture packaging not only as a protective device but also as a means of merchandising his product and as a definite support in modern furniture production technology.

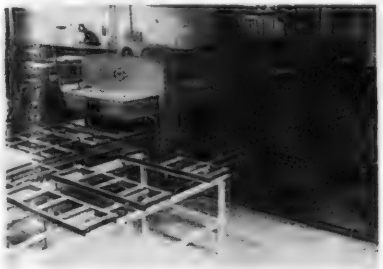
Growing competition among rail and highway carriers is made keener by the difference in approach to the furniture manufacturers' packaging problem by these two methods of transportation.

Furniture packaging is a dynamic art and will certainly change radically in the years to come. Wise manufacturers will concentrate as seriously on packaging improvement as on other problems and processes in their business.

FPRS News-Digest, Continued

Giant Hydraulic Hot Press

A single-opening hydraulic hot press with a platen area 50 by 288 inches was recently installed in the Brunswicke-Balke-Collender Co. plant, Marion, Va. Engineered and built by Fjellman American, Inc., Joliet, Ill., the press was designed to produce folding partitions for auditoriums, gymnasiums, and similar uses.



Each of the six frames has two hydraulic cylinders and develops 60 psi. To facilitate handling large partitions, the press is fitted with unloading, lay-up, and discharge tables. The tables are mounted in the floor with special folding gates between them to permit handling partitions from the lay-up table to the in-and-out feed table in front of the press.

New Dry Kiln

Advanced construction and operational advantages are reported in a new dry kiln described in a bulletin published by The Wel-Dri Co., Memphis, Tenn. Pre-lubricated equipment is used throughout, including an oilless compressor which delivers oil-free compressed air for instrument operation. High-speed airplane-type propeller fans are standard equipment. Direct-connected motors are said to eliminate belt replacement and power loss through belt and shaft arrangements.

The bulletin notes that each kiln is custom-designed but standard equipment is used throughout. Available in any size, it is pointed out that the kiln is particularly suited for small-volume operations.

Pole Preservative Bulletin

Extra service life for standing poles is the subject of a new bulletin prepared by Chapman Chemical Company, Box 138, Memphis, Tenn.

The folder describes three types of above-ground and ground-line treatment using Pentachlorophenol preservative compounds. They are: full-length treatment to stop shell rot; ground-line treatment with a grease-type preservative with 10% Pentachlorophenol to prevent ground-line rot; and pole-top treatment to prevent decay damage down the center of the pole from the top.

The preservatives described in the bulletin are particularly suited to field use, as they require no heating, penetrate well, and provide high toxicity to wood-destroying fungi and insects.

New Edger and Trimmer Line

Purchase of the "Tower" name, patents, and manufacturing machinery for lumber edgers and trimmers from Gordon Hollow Blast Grate Co., Greenville, Mich., has been announced by Ireland Mill & Supply Co., Inc., Cayuta, N. Y. Manufacture of the new line of edgers and trimmers is underway in Ireland's Cayuta factory, where the firm builds a line of sawmills.

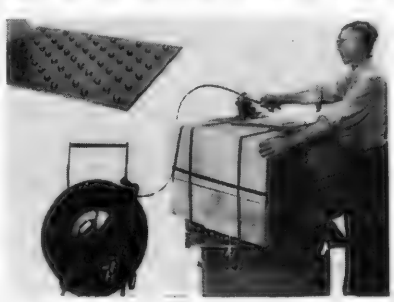
Several improvements in the machines are reported to have been made to permit easier operation, use smaller horsepower motors, and reduce maintenance. Safety features incorporated include saw guards, hoods over gear drives, and protection from other moving parts. Modern drives and couplings have been installed to keep vibration and power losses to a minimum.

Jointer Table

A heavy-duty, all-welded steel base and 64-inch long work table for the Wallace No. 10 8-inch jointer is being produced by J. D. Wallace & Co., Inc., Warsaw, Ind. The jointer is equipped with four-knived cutterheads and has 3600 rpm direct drive and 5200 rpm high-speed gear drive.

Strapping Table Top

A new strapping table top which enables the operator to stand in one position while rotating heavy containers for packing or strapping is being manufactured by Signode Steel Strapping Co., 2600 North Western Ave., Chicago. The table top may be mounted on a permanent or portable base or in conveyor lines. A metal strap guide is optional equipment to facilitate feeding the strap.



Constructed of metal-clad Haskelite, the table top contains 61 one-inch ball casters. The casters extend ¾-inch above the surface and are mounted in a staggered pattern on 3-inch centers.

High Production Shapers

A new line of high-speed shapers has been announced by Dependable Machine Co., Inc., Greensboro, N. C. Features include detachable spindles of tapered design which give accurate seating and can be quickly changed. Spindle speeds up to 15,000 rpm are reported.

The heavy table has built-in dust chute and surface-ground top, with the frame of one-piece, heavy ribbed construction. The spindles are special alloy steel, heat treated and precision ground. A large number of optional attachments are also available.

Roller Coater Bulletin

A 6-page booklet entitled "Union Roller Coaters" is available from Union Tool Corp., Warsaw, Ind. It covers a series of five coaters used in applying fluid substances to wood, metal, paper, plastic, cork, fabric, rubber, veneer, and cardboard. Complete specifications and numerous illustrations of on-the-job applications are included.

Wood Construction Booklet

A booklet designed to show planners and builders how to build better, faster, and more economically with wood is available from Timber Engineering Co., 1319 18th St. N.W., Washington 6, D. C.

The illustrated pamphlet, "Specify Timber," shows wood's versatility as an engineering material for commercial, industrial, and recreational structures.

The 24-page booklet illustrates applications of the Teco connector system in clear-span roof construction that

FPRS News-Digest, Continued

range from the small suburban store to the massive aircraft hangar with roof trusses spanning 250 feet and more.

Building News

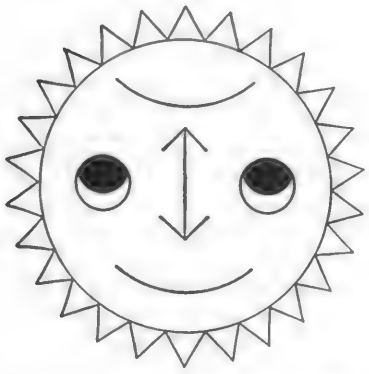
"Building Business", a new publication for the light construction industry, is being published semimonthly by the United States Plywood Corp. It presents news from government reports, trade publications, and the company's own product developments. Builders can receive this publication by writing U. S. Plywood Corp., 55 W. 44th St., New York 36.

High Pressure Pipe Strainers

New Y-type pipe strainers for oil, gas, air, water and steam lines which are suitable for pressures to 900 lbs. and temperatures to 900° F. have been developed by Armstrong Machine Works, Three Rivers, Mich.

The strainers are available in six sizes from ½ inch through 2 inch, either screwed or socket weld. Screens are standard .045 inch diameter holes or 24 by 110 wire mesh. A stainless-asbestos gasket locked between the body and the base of the bushing reportedly eliminates any chance of blowout.

The tragic fact, our doctors tell us, is that every third cancer death is a needless death... *twice* as many could be saved.



LET'S LOOK AT THE BRIGHTER SIDE

Many thousands of Americans are cured of cancer every year. More and more people are going to their doctors *in time*...To learn how to head off cancer, call the American Cancer Society or write to "Cancer" in care of your local Post Office.

American Cancer Society

Wood Drying Aids

Three new products to aid dry kiln operation and maintenance are described in a folder, "3 Corkers", published by Universal Door Carrier, Inc., 1117 Cornell Ave., Indianapolis 2, Ind.

The products are a kiln door gasket, not susceptible to chemical change when exposed to heat and oxidation; rubber-to-steel cement which will withstand moisture, humidity and kiln temperatures; and a rust preventive coating, which protects structural steel and steel equipment against corrosion due to water, steam, and most corrosive chemicals.

NEW PUBLICATIONS

European Trade Ways. H. G. Uhl, Timber Engineering Co., 1319—18th St., N. W., Washington 6, D. C. Gives an appraisal of conservation practices, manufacturing methods, and economic factors in the wood-using industries of Europe and Scandinavia.

Publications of Organization for European Economic Cooperation and European Productivity Agency. O.E.E.C. Mission, 2000 P St., N. W., Washington, D. C.

Meet Informin' Norman. 1955 Annual Report, Central States Forest Experiment Station, Columbus, Ohio.

The Colorado Experimental Charcoal Kiln. H. E. Troxell and C. W. Barney. Research Note No. 3, School of Forestry and Range Management, Colorado A & M College, Fort Collins, Colo.

Wood Residue from Primary Wood-Using Industries in California. R. H. May and L. N. Ericksen. Tech Paper 13, California Forest and Range Experiment Station, Berkeley, Calif.

Canadian Wood at Work. Department of Trade and Commerce, Ottawa, Ont., Canada. Discusses 18 species of wood exported from Canada, some of end uses, best varieties for each purpose, and important characteristics of various species.

Sulphite Roadbinder. Lake States Roadbinder Assoc., Box 346, Appleton, Wis. Describes application methods, maintenance, and economic factors of using sulphite pulping by-product as road building material.

Engineering a 43-ft. Wood Box. L. N. Sledge, W. R. Ganser, Jr., and T. G. Gill. *Wood Research,* reprint from Modern Packaging. Timber Engineering Company, 1319–18th Street, N. W., Washington 6, D. C.

Hough's Encyclopaedia of American Woods. Dr. E. S. Harrar. The Colonial Press, Robert Speller & Sons, Publishers, 1201 West Chapel Hill St., Durham, N. C. Vol. I & II, $15.00 per volume. Volume I contains actual wood slicings and text covering 25 coniferous species: Volume II contains wood slicings and covers 25 hardwood species.

Preservative Treatment on Fence Posts by Cold-Soaking in Pentachlorophenol—Fuel Oil Solutions. C. S. Walters and K. R. Peterson. Forestry Note 63. U. of Illinois Agricultural Experiment Station, Urbana, Ill.

Diameter Growth of Shortleaf Pine and White Oak Following a Mid-Season Drought. W. R. Boggess. Forestry Note 65. U. of Illinois Agricultural Experiment Station, Urbana, Ill.

Unloading Chips at the Mill. Equipment Handbook Release 245, American Pulpwood Assoc., 220 E. 42nd St., New York 17.

Animal Skidding. APA Training Guide No. 6. American Pulpwood Assoc., 220 E. 42nd St., New York 17.

The following publications are available without charge from the U. S. Forest Products Laboratory, Madison, Wis.

Glued and Nailed Roof Trusses for House Construction. R. F. Luxford and O. C. Heyer. Reprint from Symposium on Methods of Testing Building Constructions, No. 166, American Society for Testing Materials.

Prospective Wood Quality and Species Requirements in Forest Industries. J. A. Hall. Reprint from Proceedings, Society of American Foresters.

Nitrobenzene Oxidation of Lignin Model Compounds, Spruce Wood and Spruce "Native Lignin". J. C. Pew. Reprint from Journal of American Chemical Society.

PROFESSIONAL CARD

W. H. RAMBO
INDUSTRIAL PLANT ENGINEER
Specialist in
Furniture & Woodworking Plants
Sawmills, Veneer Plants
Paper Mill Wood Rooms
Hard Board Plants & Wood Preserving Plants
Design, Supervision of Construction
Reports & Surveys
Loyalty Bldg. Portland 4, Ore.

Trends in the Veneer and Plywood Industry of the North Central States. T. R. Truax and H. O. Fleischer. Reprint from Proceedings, Society of American Foresters.

Structural Performance Requirements in Housing Codes. L. W. Wood. Reprint from Symposium on Methods of Testing Building Constructions, No. 166, American Society for Testing Materials.

First Report on Tests of Service Life of Poles in REA—Financed Electric Systems. J. W. Kulp and J. O. Blew, Jr. Results of tests will show the effect on pole life of environmental condition; preservatives, treatment methods, species, and time in service.

Supplement to Mechanical Properties of Plastic Laminates. F. Werren. Report 1820–B. Presents results of tension, compression, bending, bolt-bearing, and interlaminar shear tests of two parallel-laminated epoxide laminates.

List of Manufacturers and Dealers for Log and Lumber End Coatings. Report 1954.

Some Common Fallacies About Wood. Report 1167. Refutes common misconceptions that wood naturally decays with age, that wood construction is more susceptible to damage by fire than steel construction, or that wood becomes brittle as glass at low temperatures.

Color Test for Early Storage Decay in Southern Pine. R. M. Lindgren. Report 2037. Describes a test for detection of infection by the common decay fungus *Peniophora gigantea.*

News and Views of This Kiln Drying Business. Report 1769–17 by G. Westerholm describes fork-lift piling of lumber packages without bolsters. Report 1769–18 by J. Owens describes method of splitting and breaking lumber when kiln charges are loaded and unloaded by power winch and cable. Report 1769–19 by W. A. Kinney reports on loading and unloading track-type dry kilns with a lift truck.

Forest Products Laboratory Resin-Treated Wood (Impreg). A. J. Stamm and R. M. Seborg. Report 1380. Discusses properties of impreg and suggests applications for use such as patterns and die models.

Procedure for Determining the Properties and Characteristics of Pulpwood. Report 1417.

Debarkers Used in the South and East. R. H. P. Miller. Report 2038.

A Comparison of Two Methods for Determining the Specific Gravity of Small Samples of Second-Growth Douglas-Fir. D. M. Smith. Report 2033. Compares the maximum-moisture and water-immersion methods of determining specific gravity.

EMPLOYMENT SERVICE

Positions Offered

No. E 220—San Francisco sales agent of special products — lumber, particle board, pallets, seeks young men as sales trainees. (Mch)

No. E 221—Leading Midwest millwork company seeks men, age 25–35, for product design department. Prefer mechanical engineering or chemistry background. (Mch)

No. E 222—Large southern lumber manufacturer seeks experienced young men for two positions—one leading to superintendent of production in furniture dimension plant; other, as assistant to vice-president leading to sales management. (Mch)

No. E 223—Leading Southern wood preservation organization seeks young man for research laboratory. After 1½ years research on pressure treatment of wood, he will tansfer to technical service. (Mch)

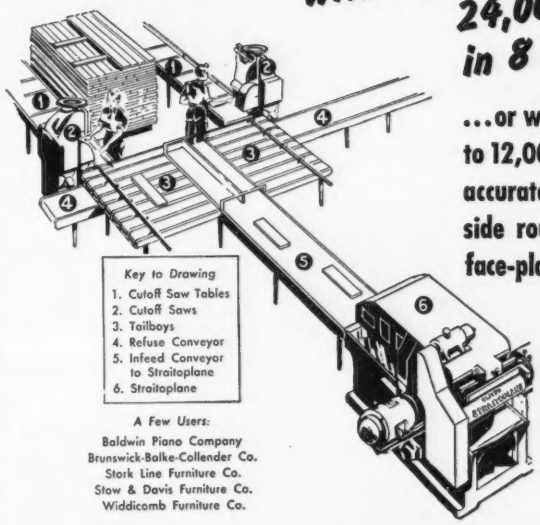
No. E 224—Southeast textile plant desires man, age 25–30, M.S. in Wood Technology or Engineering as research

Plan now with Oliver engineers to get the most production for your dollar!

"OLIVER" CONVEYORIZED ROUGH MILL

with 3 men can process 24,000 ft. of lumber in 8 hours

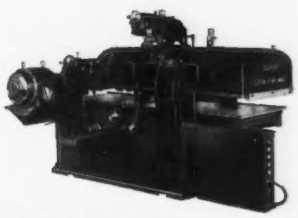
...or with 2 men from 6,000 ft. to 12,000 ft. in one day. Stock is accurately sawed to length, one side rough surfaced, other side face-planed to correct dimension



Key to Drawing
1. Cutoff Saw Tables
2. Cutoff Saws
3. Tailboys
4. Refuse Conveyor
5. Infeed Conveyor to Straitoplane
6. Straitoplane

A Few Users:
Baldwin Piano Company
Brunswick-Balke-Collender Co.
Stork Line Furniture Co.
Stow & Davis Furniture Co.
Widdicomb Furniture Co.

"Oliver" automatic Cutoff Saw makes up to 43 cuts a minute. Hydraulic operated. Has wide capacity. Makes cuts without .005 inch variation.



Straitoplane removes warp or wind from stock, rough surfaces one side, face-planes other in one operation. Takes stock to 36" wide, ½" to 6" thick, from 16" up in length. Feed: 20' to 60' or more a minute. Processed stock is straight, flat, uniform.

- Using an "Oliver" conveyorized layout, two men running two Cutoff Saws and one man to tend the Straitoplane can turn out up to 24,000 ft. a day. With one man at a Cutoff Saw, up to 12,000 ft. a day.
- This system is most efficient for processing rough lumber from bunk through surfacer. It gives flat, uniform stock. Cuts manpower, speeds production. Avoids unpiling and repiling on trucks.
- The "Oliver" layout can be changed to meet your special needs. If you produce 4,000 ft. or more a day, get all the facts on this Conveyorized Rough Mill system.

OLIVER MACHINERY COMPANY, GRAND RAPIDS 2, MICHIGAN

laboratory supervisor. Should have 2–5 years experience with glues. Excellent starting salary. (Mch)

No. E 225—Large progressive Texas firm plans training program to develop production management personnel for South's newest and largest all-electric forest products plant. Seeks recent or June 1956 forest utilization graduates interested in fields of power generation, product shipment, machine finishing and primary production. (May)

No. E 226—Research position requiring Ph.D. or equivalent in wood technology or pulp and paper for Group Leader in Research Center. Strong background in chemistry and understanding of polymeric materials desirable. Reply in confidence enclosing complete resume to the Borden Co., Chemical Division, Philadelphia Research Lab. P. O. Box 9524, Philadelphia 24, Pa. (May)

No. E 227—Machinery company desires forester trained in wood utilization to sell line of fiber preparation equipment in Southwest. Should be 35 years of age or older. Also openings in Midwest and Eastern territories. (Apr.)

No. E 228—Furniture component manufacturer utilizing plastics has opening for fabricating department supervisor with opportunity to advance to general plant supervision. Supervisory ability and wood fabricating experience primary requisites. 50 to 100 employees. Located in small city in southern lake section of Wisconsin.

Employment Wanted

No. 338—Wood Technologist, age 27, three years experience in research laboratory and with chemical company. Good background in lumber, veneer and particle board. West Coast. (Mch)

No. 339—Experienced lumberman, age 37, seeks supervisory position. Thorough knowledge of production costs, utilization, and sales in soft wood and hardwood mills. B.S. Forest Products. (Apr)

No. 341—Graduate, Wood Utilization, Eastern College, 1954. Former NLMA scholarship winner. Some experience furniture. Seeks research or production position. (Mch)

No. 343—June, 1956 graduate, Forest Management, Colorado A. & M. Available June 15. Prefers forestry research or management. Single. West or North. (Mch)

No. 345—Young man, B.S. in agriculture, will receive Master of Forestry in forest products from Duke University in June 1956. Seeks immediate position in production or sales in Northeast. Age 27, married. (Apr)

No. 349—Graduate of New York State College of Forestry and National Hardwood Inspection School, age 28, seeks position as yard manager and purchasing agent for hardwoods in East or South. Has six years experience as inspector, kiln operator. (Apr)

No. 350—Experienced lumber superintendent and kiln operator, age 40, graduate of Oregon State College of Forestry, seeks West Coast buying and sales position in wholesale lumber field. Has been in charge of drying, surfacing, and shipment of hardwood and softwoods, some sales. Holds commission in U.S.N.R. (Apr)

No. 351 — Lumber manufacturing executive extensively trained in chemistry, wood technology, and wood utilization with advanced degree from Yale seeks research or manufacturing position. (Apr)

No. 352—Young executive, commerce degree and 20 years' experience in furniture production, design, labor relations, purchasing and sales as general manager, seeks position in South or Southwest, will consider other areas. (Apr)

Two New Tools for *Precision* Veneer Cutting

PRECISION KNIFE ANGLE INDICATOR

PRECISION HORIZONTAL OPENING INDICATOR

Investigations show that smooth, accurate veneer can be cut consistently when these two precision instruments are used to set knife angles and horizontal opening between knife edge and nosebar. By keeping records of settings that give the best results, even a novice can acquire the skill necessary to cut good veneer consistently.

For Information, Prices, Write

WFM **WISCONSIN FOUNDRY AND MACHINE COMPANY**
623 E. Main St. Madison, Wis.

INDEX TO ADVERTISERS

	Page
American Cancer Society	30-A
Berthelsen Presses	4th Cover
Behr–Manning Corp.	3rd Cover
Black Brothers Co., Inc.	2-A
Borden Company	12-A
Buss Machine Works	4-A
Chapman Chemical Co.	2nd Cover
Columbia Engineering Co., Ltd.	9-A
FPRS Paul Bunyan Activities	9-A
Monsanto Chemical Co.	10-A
National Starch Products Co.	3-A
Oliver Machinery Co.	31-A
W. H. Rambo	30-A
Standard Dry Kiln Co.	11-A
Wisconsin Foundry and Machine Co.	32-A

For the newest in coated abrasives . . . watch BEHR-MANNING!

Garnet Finishing Paper is tops for all your hand sanding operations.

Adalox Belts are favorites for cleaning up rough edges and glued areas.

Tufbak Paper is a natural for wet-sanding between coats.

Sanding curves right on the nose!

A BEHR-MANNING Abrasive Belt powered over a stationary nose block by an Upright Spindle Sander does the job quickly and easily on this wood mirror frame. This is a typical example of the successful results obtained when the right BEHR-MANNING coated abrasive is teamed with up-to-date machinery and methods.

Though your operations may be different, a BEHR-MANNING Field Engineer will gladly survey your problem jobs . . . suggest a solution . . . and prove his recommendation right in your plant. Write Behr-Manning, Troy, N. Y., Dept. FP-3.

In Canada: Behr-Manning (Canada) Ltd., Brantford.
For Export: Norton Behr-Manning Overseas Inc., New Rochelle, N. Y., U. S. A.

W-1

BEHR-MANNING® *division of NORTON Company*

▲ COATED ABRASIVES
▲ SHARPENING STONES
▲ PRESSURE-SENSITIVE TAPES

BERTHELSEN...

PACE-SETTER

. . . in precision press engineering

BERTHELSEN ENGINEERS **have developed a 2" chambered hot platen for use with any heating medium . . .** ***a revolutionary concept in hot plate press design.*** **No other platen construction can offer greater controlled uniform temperatures over the entire pressing area in any temperature range.**

This is just one of many reasons why *BERTHELSEN* sets the pace in press engineering today.

Investigate how BERTHELSEN can engineer presses to do specific special jobs utilizing Berthelsen "*know-how*" and modern production techniques to your advantage and profit. Write today for further information.

BERTHELSEN PRESSES

P. O. BOX 1423 • LOCKPORT ROAD • JOLIET, ILLINOIS